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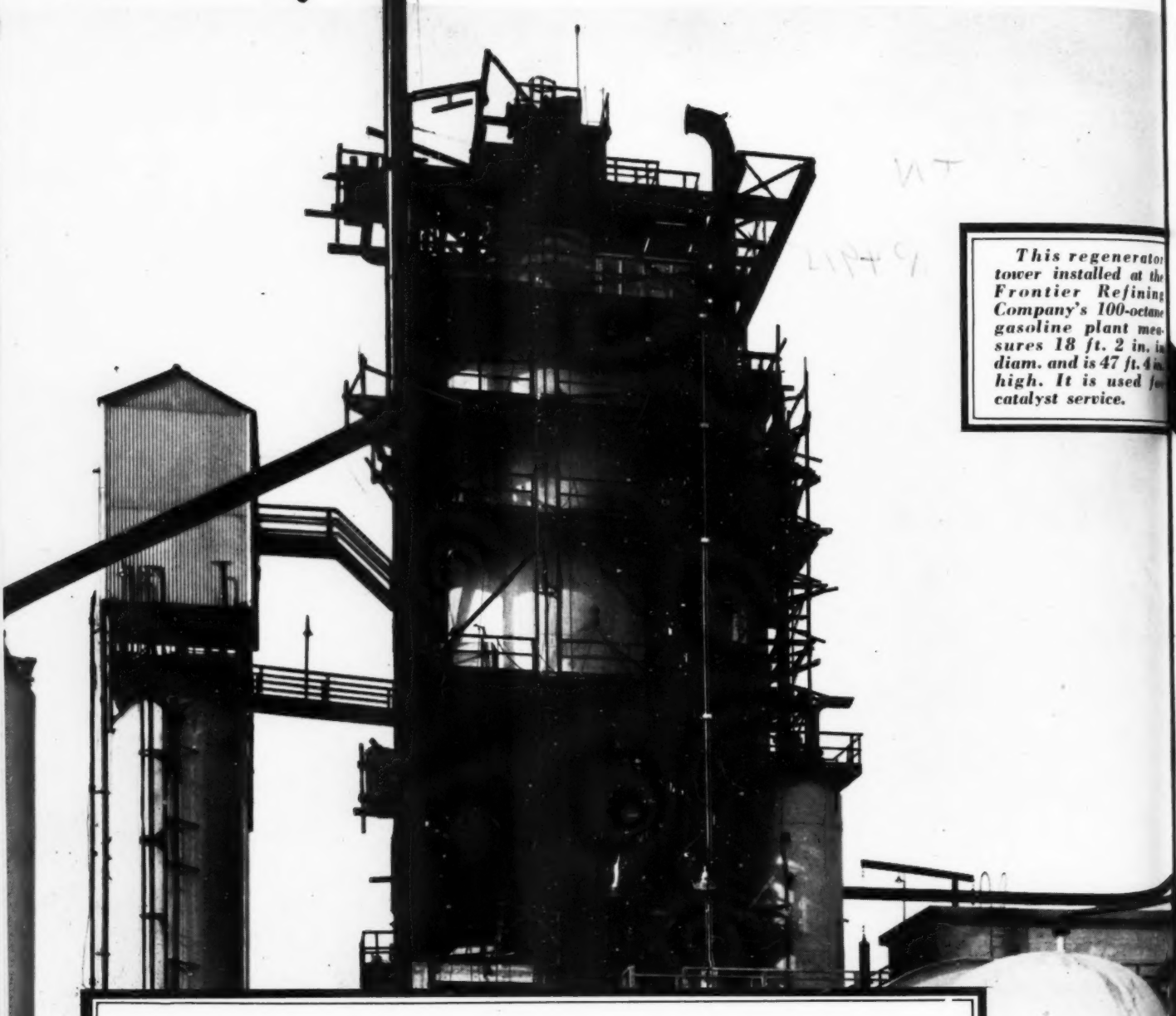
TRANSFORMING *Rocky Mountain Crude* into 100-Octane Gasoline...



This regenerator tower installed at the Frontier Refining Company's 100-octane gasoline plant measures 18 ft. 2 in. in diam. and is 47 ft. 4 in. high. It is used for catalyst service.

When the Frontier Refining Company worked out plans to convert products from Rocky Mountain crude oil into 100-octane gasoline they installed, among other equipment, a catalytic cracking unit with an 18-ft. 2-in. diam. regenerator tower fabricated at our Birmingham plant. This refinery vessel has helped immeasurably in the production of superfuel.

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Another interesting product of chemistry is Tret-O-lite, which serves the oil industry in the dehydration of crude oil and water emulsions. Oil producers, everywhere, have long benefited by Tret-O-lite's effective, economical and fast performance—plus the competent services of Tret-O-lite field engineers.

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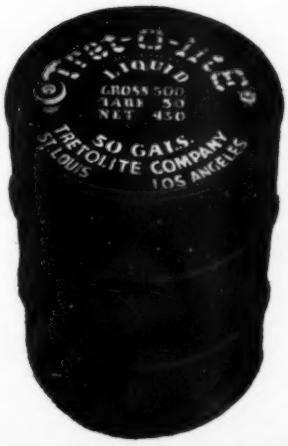

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DEHYDRATING **DESALTING**

MEETINGS

June 24—Kentucky Oil and Gas Association, mid-year meeting, Lexington.

June 26-30—A.S.T.M., annual meeting, Waldorf-Astoria, New York, New York.

June 30-July 1—Interstate Oil Compact Commission, quarterly meeting, Shirley-Savoy Hotel, Denver, Colo.

July 6—California Natural Gasoline Association, monthly meeting, Rio Hondo Golf Club, Downey, California.

September 20-22—N. P. A., annual meeting, Hotel Claridge, Atlantic City, New Jersey.

October 2-5—A.S.M.E., fall meeting, Cincinnati, Ohio.

October 3-4—American Association of Oilwell Drilling Contractors, 1944 meeting, Fort Worth, Texas.

October 12-13—Texas Mid-Continent Oil and Gas Association, Rice Hotel, Houston, Texas.

October 13—California Natural Gasoline Association, annual meeting, Biltmore Hotel, Los Angeles.

October 23-25—I.P.A., annual meeting, Dallas, Texas.

November 13-16—A.P.I. annual meeting, Stevens Hotel, Chicago, Illinois.

March 12-14, 1945—National Association of Corrosion Engineers, President Hotel, Kansas City, Missouri.

★ Dr. Herbert Feis, economic adviser to the U. S. Department of State, balances the pros and cons of Arabian oil and American policy in a paper given recently and published in this issue. As Doctor Feis implies, it would take a diplomatic detective to follow the complex relationships that run through the situation. He does a good job of clarifying the characters and their roles and points out the angles of the stage to be watched.

* * *

★ ***Some interesting statistics given by S. F. Shaw show that oil reserves in many U. S. fields have been estimated too high. If this is general a more serious study of our reserves is indicated.***

* * *

★ The extraordinary collection of technical papers in the Reference Annual of *The Petroleum Engineer*, publication date July 1, makes it one of the outstanding volumes of the year in the petroleum industry.

THE Petroleum Engineer

June, 1944

Vol. XV No. 9

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THE PETROLEUM ENGINEER PUBLISHING COMPANY

Irwin-Keasler Building, Dallas 1, Texas **Phone: Central-4571**

EXECUTIVE—W. L. LOVE, *president*; W. T. BRYAN, *general manager and treasurer.*

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ADVERTISING—T. J. CROWLEY, *vice president and advertising manager.*
New York—ROGER MOTHERAL, 52 Vanderbilt Avenue, New York 17, N. Y., MUrray Hill 4-1880.
Chicago—E. V. PERKINS, 330 South Wells Street, Chicago 6, Ill., HARrison 1843.
Los Angeles—R. C. WIPPERMAN, 518 North Sweetzer, Los Angeles 36, Calif., Webster 9617.
Dallas—JOE B. WOODS, Irwin-Keasler Building, Dallas 1, Texas, Central-4571.

CIRCULATION—C. R. BARRETT, *circulation manager.*

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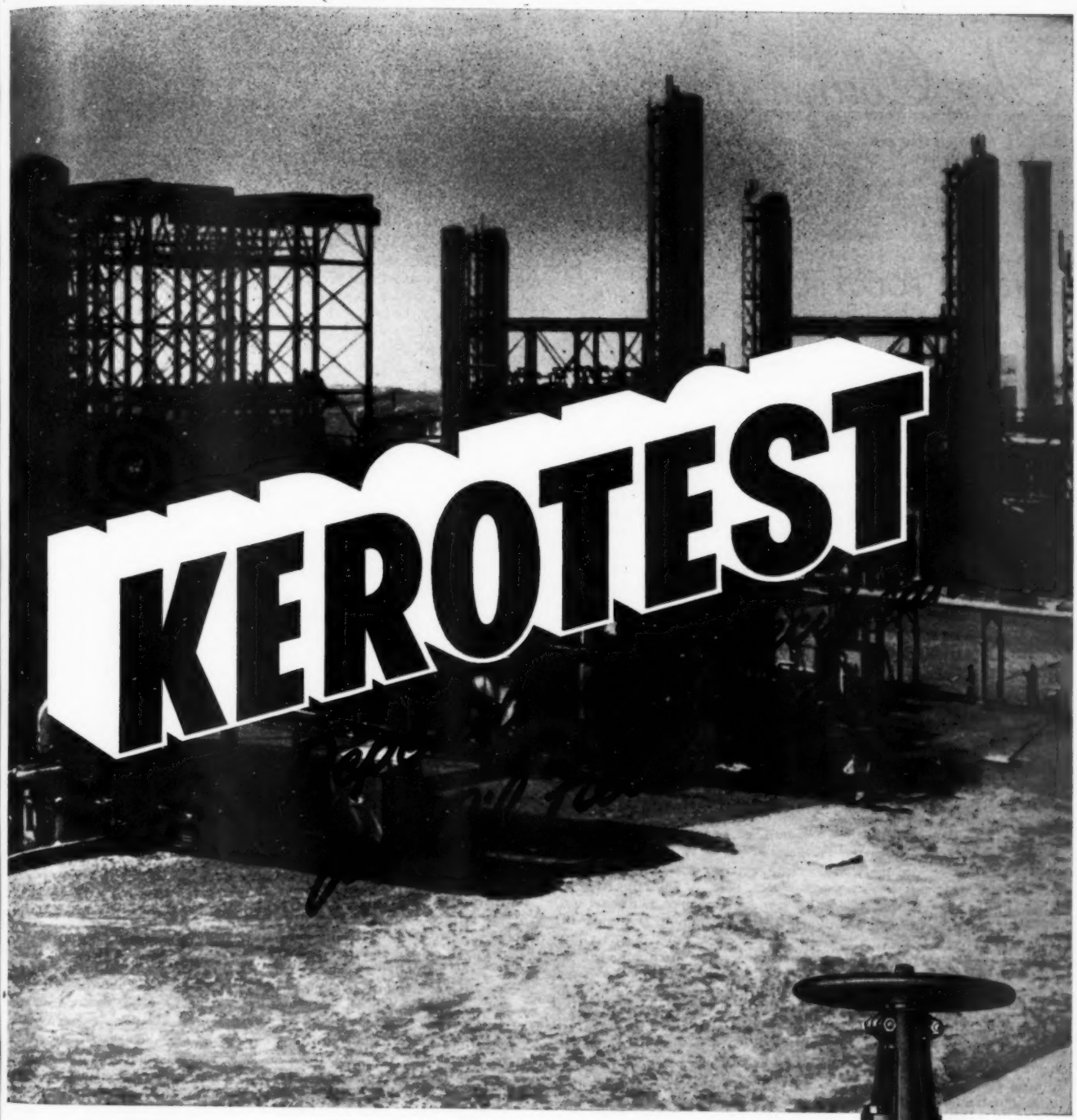
Articles in The Petroleum Engineer are indexed by Industrial Arts Index

A. B. C. SUBSCRIPTION: 1 year, $2 — 2 years, $3 A. B. P.



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The Course of Oil

Here is a forthright and pertinent discussion of an international question, the manner of settlement of which will have a profound influence on the entire future of the world petroleum industry. It is taken from a booklet, *Oil for the World,* by Standard Oil Company (New Jersey). Worth noting is the fact that the suggestions presented for an enlightened world oil policy take into account adherence to and fulfillment of the principles of the Atlantic Charter, basic considerations in any future international agreements. The viewpoints presented merit close study.

WORLD OIL POLICY

We are fighting a war for survival which requires the expenditure of billions of barrels of oil. We want not only to survive but also to thrive. Oil turns the wheels of peaceful prosperity as well as those of military machinery. Our need for oil, consequently, will continue to grow.

The pre-war world consumed nearly 2,000,000,000 barrels of oil a year, or almost a barrel per person. This oil floated the world's merchant marine, drove our motors, and made the cheap transportation and productive labor possible which gave the American people the highest standard of living ever attained. Now our leaders speak of freedom from want and fear. We expect the standard of living of more people to rise. We hope to travel swifter, safer and more luxuriously, and encounter less human misery, in the post-war world. This means that there must be further increases in the productivity of human labor, which oil can make possible.

The world's proved oil reserves would be used up within 10 years, however, if the whole world's standard of living, along with the consumption of oil per person, were to be raised tomorrow to a level only half as high as our own. In the world which we now envision, several times 2,000,000,000 barrels of oil a year will be needed. We must, therefore, find more oil and permit no waste.

We can do both. We have scientific evidence that there is plenty of oil somewhere beneath the earth's surface. We have learned how to find it and how to conserve it. But a comprehensive and enlightened world oil policy is needed to assure the discovery and efficient use of this vital resource.

It must be a world policy because there is oil in many parts of the world. The United States has supplied three-fifths of mankind's oil in the past, but cannot keep this up forever. Russia has great unexplored and undeveloped reserves, but Russia is likely to need that oil for her own further development as rapidly as those sources can be tapped. Outside of the U. S. and U. S. S. R., the principal proved reserves are in the Near East, around the Gulf of Mexico and the Caribbean Sea, and in the larger islands of the East Indies in the Southwest Pacific.

The need for oil is equally world-wide. Our own peace-time requirements have increased four fold since World War I, and are steadily growing. Most of our good neighbors in Latin America need additional oil. So does China. So does India. And the need of the millions of people in those lands is urgent.

Our oil policy, therefore, must be comprehensive and enlightened. It must provide for the distribution as well as the production and conservation of oil. The Atlantic Charter proclaimed the United Nations' intention of furthering "the enjoyment by all states, great or small, victor or vanquished, of access on equal terms, to the trade and to the raw materials of the world which are needed for their common prosperity." Oil is foremost among those raw materials, and the steps to make good this pledge to the world must be taken soon.

As the outstanding oil-finding and oil-producing peoples of the world, we Americans and the British are morally obligated to point the way. The responsibility of leadership rests on us. We must formulate a policy that will result in the discovery of ample oil reserves, the most efficient use of those reserves, and the fulfillment of our promise to the people of other lands.

Our experience is illuminating. The oil resources of the United States have been developed more thoroughly than those of any other nation. This progress has been made in a climate of free enterprise. Private citizens have been permitted to exercise their initiative in the oil industry here. The right to search for oil has not even been restricted to American citizens. The people of all lands have been allowed to engage freely in the search for our oil. * * * In other countries, the citizens of certain nations have been favored and those of other nations have been hampered or excluded. The results have been less satisfactory than those obtained in the United States. State monopolies, restraints and discriminations—regardless of the motives for them—have retarded the discovery and development of oil fields.

To stimulate the finding and testing of possible sources of the vast quantities of oil that the world will need after this war, it is advisable, therefore, that freedom of enterprise be encouraged. The record of the past shows that the American way is the most effective way of locating oil.

The discovery of more oil is not only one of our objectives but also a pre-requisite to the conservation of oil. Quite meager reserves can supply a tremendous demand in a pinch, but this is likely to result in waste. * * *

Suppose, however, that adequate reserves are found. What then is to prevent an uncooperative operator or nation from producing oil faster from his or its reserves than is efficient? A sound world oil policy, therefore, should provide for limitation of yearly withdrawals from the earth's proved reserves to the world's annual requirements.

Again, fortunately, American experience suggests a way to do this without curbing enterprise or retarding the oil industry's progress. Under the conservation laws of the states where oil is produced in this country, and the covenants of the Interstate Oil Compact, made with the approval of Congress, our national demand for oil is supplied by ratable withdrawals from the oil fields of the several states. Under this system, the governing authorities of Texas, for example, fix—in open public hearings—quotas for the production of oil within the state.

By cooperation between nations, similar to that between our states, wasting of the world's oil reserves can be prevented. The authority of no nation need be abridged. Assent and adherence to a policy serving every nation's best interests can be attained voluntarily, if that policy is clearly presented and understood. We can offer and explain such a policy. No use of force should be contemplated or needed.

This, then, is the sort of world oil policy which we should propose and expound: A policy based on freedom of enterprise to promote the discovery of oil, and a policy based on international cooperation to prevent squandering of a resource essential to the world's prosperity.

Equality of access by all nations to this vital raw material is our third goal. This can be attained only in a free international economy. The surplus oil of the producing countries must be available to each and every consuming country. Our government can contribute directly to the establishment and continuance of such an economy by giving the support of its diplomacy to those of its citizens who seek to engage in legitimate business throughout the world. * * *

In seeking to participate in the development of the oil resources of other nations in the past, American citizens have asked for security of title to the property or rights acquired, managerial control of their own operations, and the chance to make a reasonable profit. Our government can support them in negotiations for such legitimate assurances.

Given these assurances, American citizens' agreements with the governments of other lands may provide for the payment of royalties to those governments, or the sharing of profits, or for joint operations by the companies and the governments, or for the admission of local capital to the enterprise.

Foreign governments may properly insist on adequate participation in the benefits from ventures on their soil. It is reasonable for them to require operations to be so conducted as to contribute to their own domestic economies, and to demand that their own requirements for oil be satisfied fully at low prices before any oil is exported. They are entitled, also, to guarantee that there will be no avoidable waste of the oil beneath their land, that their people will receive a maximum of training and employment at fair wages from the enterprise, and that such oil as is available for export be put on the market in fair volume at fair prices.

The American government should insist, of course, that its citizens be accorded whatever reasonable rights their contracts with foreign governments give them, judged by the laws of those governments; and that Americans live up to their obligations and so conduct themselves as to contribute to the welfare of the countries in which they operate. Our government should also assure itself that the activities of its citizens in other lands be in accord with our interests; that there be no needless waste of other people's oil; that the exportable surpluses move efficiently, in an orderly manner and at fair prices, into the world markets; and that the importation of oil into the United States not be destructive to our own oil industry and domestic economy.

When oil or oil products must be imported to supplement the domestic supplies of the United States, this should be done without so damaging our industry that the finding and development of reserves here would be hampered. Hence, imports should be admitted only for special purposes or to supply requirements that could not be met by orderly and efficient withdrawals from American fields.

Thus we can provide enlightened leadership to other nations, yet permit every nation to write its own laws and prescribe for itself the conditions under which private citizens, whether native or foreign, should be permitted to participate in the development of its oil resources. Each exporting nation should determine for itself the volume of oil or oil products required for internal consumption. And if adequate world reserves were found and used intelligently, the surpluses of the producting nations would flow first to one, then another, of the consuming nations in response to the urgency of their demands. * * *

Our government can discourage the erection of barriers to world prosperity by encouraging practices shown by our experience to be beneficial. We can collaborate with other governments to establish and maintain orderly production from oil reserves throughout the world for the benefit of the people throughout the world who require oil. A policy beneficial to one nation at the expense of others would fail.

We are at war now because our enemies adopted policies devised to benefit them by enslaving others. We must evolve policies beneficial to all mankind. An enlightened, comprehensive, world oil policy would stimulate the free exploration for oil, prevent the wasteful depletion of known reserves, and provide for fair disribution of oil and oil products to give all men greater freedom and opportunities.

The adoption of such a policy now would be as firm a step as any that can be taken toward realization of our vision of a peaceful and prosperous world.

The Fairbanks-Morse Type ZC Oil Field Pumping Engine shown at the left is the ZC-208 size, and is fitted with carburetor for gas and gasoline operation. It has vapor cooling, cast iron subbase, easily adjusted variable speed governor, controlled splash lubrication, two extra heavy flywheels, roller main bearings, Fairbanks-Morse super spark high tension magneto and exhaust muffler. Crankcase cover is easily removed for accessibility to all working parts.

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Buy extra bonds. Save and prepare every bit of waste paper. Don't waste even a spoonful of used kitchen fats. Add to your Red Cross donation. Work harder! Sacrifice for God and country.

There should be no grandstands in the grim game of war, no onlookers. Every man, woman, and child is needed in the line marching to Victory and Freedom!

Interstate Compact Meeting

The Interstate Oil Compact Commission will meet at Denver, Colorado, June 30-July 1, for its summer quarterly meeting, Chas. L. Orr, secretary, announces.

Arrangements for all sessions to be held in the headquarters hotel, the Shirley-Savoy, have been completed by Judge Warwick M. Downing, Colorado's long time member of the compact commission, Orr said.

During its two-day open sessions the commission will hear eminent authorities discuss public lands and oil and gas prospects in the Rocky Mountain states.

The commission's executive, legal, research, engineering, regulatory practices, interstate relations, public lands, and economics advisory committees will convene June 29 and 30 to discuss committee matters and prepare their reports and recommendations.

Army Trains Specialized Oil Field Forces

Oil men who have long wondered just what steps would be taken to restore to productivity recaptured oil fields now in enemy hands now have their answer. The United States Army has organized a special branch of the Engineers Corps to take over and cope with the special problems of getting sabotaged oil fields back into production immediately after they are taken from the enemy.

Oil field men, both officers and men, are being drawn into special army organizations for this purpose. At the Santa Anita, California, Army Ordnance Depot, the first engineer petroleum production depot has been established.

Col. E. S. J. Irvine, a West Pointer and engineer, is commanding officer. His executive officer is Lt. Col. R. G. McDonald. Ninety per cent of the officers and 75 per cent of the enlisted men were oil field personnel before entering the army. Most of them are from the Mid-Continent area—Oklahoma, Texas, and Louisiana. The organization is set up to handle oil from getting it out of the ground through to the finished product ready for army utilization.

Battalions are organized for oil field and refinery work. Certain companies are designated for refinery tank construction and pipe fitting. The outfit is expected to be able to drill 100 wells a year to a depth of from 1000 to 4000 ft.

The refinery battalion will be able to build, operate, and maintain a refinery with a capacity of 20,000 bbl. of crude oil per day.

Practical training for the organization is going forward on the Stearms lease of the Union Oil Company at Brea-Linda, where a large acreage has been turned over to the army by the Union Oil Company for operations.

Latest oil field equipment is in use, all painted olive drab and bearing army markings.

Lube Thickens When Heated

A new type lubricating oil that thickens when heated and thins when cooled has been developed in the Richmond, California, laboratories of the California Research Corporation, a Standard Oil of California subsidiary.

Although the new oil still is looked upon as somewhat of a laboratory curiosity, it may help solve the problem of lubricating equipment operating at wide temperature range.

Aircraft often encounter extreme heat and extreme cold within the space of a few minutes. Bombers may take off, as they did in the North African campaign, from an air base where the temperature reads 120° F. and climb to an altitude of 30,000 ft. into a paralyzing temperature of minus 75° F.

Lubrication of moving parts, such as bomb bay doors, retractable landing gear, camera equipment, etc., is a serious problem when there is a wide range between ground temperature and temperature aloft. Likewise oil that gives good cold weather performance may be too thin to protect frictional surface at desert floor temperatures. The same problem is found in lubrication of railroad journal bearings on trains passing from mountain blizzards into desert heat.

Montana Expands Field Division

The Board of Railroad Commissioners and Oil Conservation Board of the State of Montana have divided the state into two districts for the purpose of supervising the drilling of wells for oil and gas, the production and transportation of crude oil and gas, and the storage of crude oil, and have authorized an additional field office at Billings, Montana.

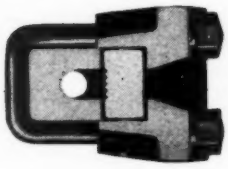
The districts will be known as the Shelby district and Billings district, respectively. The Billings district includes all fields and lands in the counties of Big Horn, Carbon, Carter, Custer, Dawson, Fallon, Fergus, Gallatin, Garfield, Golden Valley, Judith Basin, McCone, Musselshell, Park, Petroleum, Powder River, Prairie, Richland, Rosebud, Stillwater, Sweet Grass, Treasure, Wheatland, Wibaux, and Yellowstone. The Shelby district includes all fields and lands in Montana other than those in the counties allocated to the Billings district.

Fred C. Platt will continue to serve as state oil and gas field supervisor for the Board of Railroad Commissioners and field supervisor of crude oil production, transportation, and storage, for the Oil Conservation Board, with headquarters at the joint office of said boards at Shelby, Montana. He will personally supervise activities in the Shelby district and will retain his authority over field operations throughout the state.

L. G. Hinkley has been appointed assistant supervisor for the boards, with headquarters at Billings, Montana, where an office has been established at Room 510 Securities Building.

The rapidly increasing activity in oil and gas field operations in Montana developing during the last six months, especially in southern Montana, has necessitated the expansion of the field division to provide the supervision required to assure timely compliance with the operating and producing regulations, it is announced.

Alike in Quality



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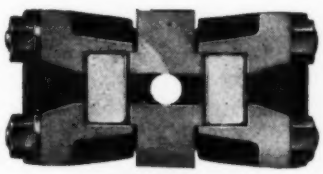

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PENBERTHY PRODUCTS

MAJOR *Pipe Line* ACTIVITIES

THE 65,000-gal. daily capacity petroleum products plant of the Natural Gasoline Corporation of Tulsa, Oklahoma, and Humble Oil and Refining Company of Houston, Texas, in the Hawkins field of Wood County, East Texas, about 12 miles east of Mineola, has been placed in operation with the completion of 100 miles of pipe line gathering and distribution system in the field.

The plant, processing 15,000,000 cu. ft. of natural gas daily, is manufacturing natural gasoline, isopentane, normal butane, isobutane, and propane. The 5 products, carried in 5 separate pipe lines from the plant, are being delivered to the railroad shipping point at Hawkins on the Texas and Pacific Railroad.

Anderson Brothers, pipe line contractors of Tulsa, Houston, and Hamilton, Ohio, constructed the pipe line gathering and distribution system. Pipe ranged in diameter from 2 to 24 in. The distribution line, carrying the products to the shipping point, is called the "banjo line" because of the 5 strings of pipe. The pipe line system is unusual in that it transports the gas to the plant from the wells, returns the residue to the field, and also carries the products to the railroad shipping point.

A. B. Herrin of Anderson Brothers was superintendent in charge of the construction of the pipe line system with W. A. Ruis of the company, field office manager at Hawkins.

Natural Gasoline Corporation is operating the plant with Guy Barritt as superintendent and John Berton as chief engineer. It is being operated as a partnership proposition with Humble.

Pipe for a natural gas line from the Penitas field in Hidalgo County, Texas, is being strung across the Rio Grande to the first wildcat to be drilled in northern Mexico in more than two years. Petroleos Mexicanos No. 1 Mission, about 20 miles southwest of McAllen, will spud as soon as the fuel line is completed.

Stanolind Pipe Line Company has awarded contracts for the construction of the 240-mile 12-in. crude oil pipe line to be built from the Elk Basin pool of northern Wyoming and southern Montana to Casper, Wyoming. I. C. Little Construction Company of Dallas, Texas, was given contracts for the western and middle sections of the line. Sharman and Allen of Houston, Texas, has the contract for the southeastern section, which comprises about 90 miles. Midwestern Engineers of Tulsa, Oklahoma, have been working for some time on the survey of the pipe line and also of telegraph and telephone lines. Aerial Exploration Company, Tulsa, made an aerial survey of the route of the line. Pipe deliveries for the line began after the first of last month.

The pipe line will be an interstate carrier of oil for some of the crude will be carried from the Montana portion of the Elk Basin pool. The line will also provide an outlet for oil from other pools in Wyoming such as the Salt Creek field, Oregon Basin, and Little Buffalo Basin. Capacity of the line for handling high viscosity crude oil will be about 15,000 bbl. daily, it is said. The line is expected to be completed in 90 days.

Petroleum Administrator Ickes has disapproved the application filed by Pacific War Emergency Pipelines, Inc., for permission to build 986 miles of 20-in. crude oil pipe line from West Texas to Beaumont, California. He stated that requirements for crude oil in the refineries of districts closer to West Texas are increasing and would soon need all available production; that the line proposed was too large; that it could not be completed until the second quarter of 1945, and that gathering facilities, which were not provided for in the application, would require additional materials and manpower.

The West Texas-California line was proposed by a group of independent oil operators of West Texas. Olin Culberson, member of the Texas Railroad Commission, took exception to Ickes' objections, saying that the navy wanted it and needed it. Culberson said that the PAW report that West Texas wells were now producing within 47,000 bbl. daily of their maximum efficient rate, not enough for the 175,000-bbl. capacity of the proposed line, was incorrect and that the engineering department of the state commission reported that 180,000 bbl. more oil could be obtained from the Midland district.

The publication, *Business Week*, stated in a recent issue that decision in the matter rested with the length of time government officials expected the war in the Pacific to last, according to some oil men. The pipe line was proposed strictly as a war measure and the PAW decision was presumably rendered on that basis.

Standard Pacific Gas Line, Inc., has expanded its California system by laying 24,350 ft. of 16-in. pipe between Rio Vista field and San Pablo paralleling a stretch of the company's 8-in. line. The project, costing $277,000, was completed recently.

The Federal Power Commission has announced postponement of the hearing set for June 7 in Chicago on applications filed by Panhandle Eastern Pipe Line Company, Kansas City, Missouri, for certificates to construct natural gas pipe line facilities from its Michigan west line in Calhoun County, Michigan, to Albion, Michigan. The postponement was made because previous commitments prevent counsel for the Albion Gas Light Company, intervener, from attending.

Gulf has completed looping its 10-in. oil line from West Texas to Weatherford, Texas, increasing the capacity approximately 15,000 bbl. to 90,000 bbl. daily. At Weatherford some of the additional West Texas sour crude will be moved through the company's 8-in. system to Longview, to swell the amount of West Texas crude carried eastward by the Big Inch line.

Feazel and Kinsey, independent operators of Shreveport, Louisiana, will lay 7 miles of 6-in. pipe in the Carthage wet gas field of Panola County, Texas, to connect their two producers on the west flank of the field to the United Gas Pipe Line Company's Goodrich-Waskom line.

Public interest demands that oil companies continue to own and operate their own pipe lines, was the message C. R. Musgrave, vice president and director of Phillips Petroleum Company, gave members of the Institute of Transportation recently. Referring to legislature proposed by Senator Gillette of Iowa, an advocate of forcing oil companies to sell their transportation, Musgrave pointed out that movement of oil could not be guaranteed so that outside financial interests could handle pipe lines with any security. He maintained that pipe line transportation is an integral part of oil manufacturing and must remain so.

Anderson Brothers Construction Company has received the contract from United Natural Gas Company to lay 70 miles of welded 12¾-in. gas line from Mineral station to Van station in Northwestern Pennsylvania. This includes the 1200-ft. crossing of the Allegheny River. Work on the project has already begun and is expected to be completed within 60 days.

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MAJOR *Oil Field* ACTIVITIES

▶ **Oklahoma.** A shallow pool of gas and oil was discovered by Helmerich and Payne, Inc., at No. 1 Freeman, C SEC 14-1n-1w. From an unidentified sand at 1107-22 ft. the well began flowing at the rate of more than 100 bbl. daily with an estimated 1,250,000 cu. ft. of gas.

▶ **Texas.** The first Devonian Age production in West Texas was opened by The Texas Company No. 1 Hobbs, in southeastern Crane County. The discovery flowed 232 bbl. of oil in 13 hr. after acid treatment from 5300-50 ft.

▶ **Alaska.** Plans are progressing for a drilling program in Alaska. The proposal is a favorite of Secretary Ickes and a request for $1,217,000 was made by President Roosevelt for the project. The U. S. Geological Survey expects to map out the exploration program and as many as 50 tests may be drilled.

▶ **Montana.** A new well on the Gage Dome, 12 miles northeast of Roundup, is estimated to be a 5000-bbl. producer. The Northern Ordnance Company of Minneapolis No. A-2 Morris, C SW NE 15-9n-26w, was treated with acid in the Amsden lime at 5950 ft.

▶ **California.** Tide Water Associated Oil Company brought in a discovery well from the Wharton sand, proving an extension of the Mountain View field to the north. The well makes an estimated 350 to 500 bbl. per day.

▶ **Chile.** A new oil deposit is said to have been discovered near Los Alamos in the province of Arauco. Discovery was made at 990 ft. The Chilean Mining and Fuel Department has ordered a thorough survey of the finding.

▶ **Mississippi.** The new T. D. Lewis well, SE NE 30-1n-18e, of Gulf Refining Company in the Jasper County Heidelberg field is rated the largest oil producer east of the Mississippi River. Production is said to be more than the 1400-bbl.-a-day production of the discovery well, the Lewis Morrison.

▶ **Turkey.** A new oil deposit is reported to have been discovered near Ismailye, in South Anatolia. The deposit is said to be located at a great depth. Exploration has also been instigated in certain areas near Polatli and near Bolu upon advice of the Turkish Institute for Mining research.

▶ **New Mexico.** The Texas Company No. 1 Baskin, 6 miles south of the Corbin pool in Lea County, is one of the best oil discoveries in recent years in this district. It is estimated to be good for 250 to 500 bbl. of oil daily, flowing from 3555-68 ft. in the upper Permian section.

▶ **Texas.** Pecos County has a new pool opened by Humble Oil and Refining Company No. 1 O. W. Williams, 13 miles southwest of the nearest production. The new well is in C NW NE 3-114-GC and SF. Production is estimated at 150 bbl. daily from 2831-84 ft. The operator is deepening the test.

▶ **Russia.** The new petroleum field in Bashkir, autonomous Soviet republic, is rapidly gaining in importance, the Soviet press states. Three wells recently drilled are said to be yielding hundreds of tons of crude oil daily. Five wells were scheduled to have gone into operation March 1.

▶ **Louisiana.** Continental No. 1 Prairie Land and Canal, 2-1s-9w, has opened what is designated as the South Lake Charles pool, in Calcasieu Parish. It was completed for 113 bbl. condensate with 1,000,000 cu. ft. of gas daily from perforations at 10,410-20 ft.

▶ **Texas.** Opening a new Strawn sand pool in Clay County, the Bridwell Oil Company completed its No. 2 River Ranch, lot 27, Ward and Houssels survey, for 112 bbl. in 7 hr. from 4744-70 ft.

▶ **Texas.** Completion of American Republics-Houston Oil Company No. 1 H and TC fee opens a new pool in Hardin County. It is located in 189, H and TC survey and has a potential of 192 bbl. daily from the Cockfield sand at 6234-43 ft. and 6247-52 ft.

▶ **New Mexico.** A showing of 50 to 54-gravity oil has been made at 6325 ft. in the Sander Brothers No. 1 Hultman, deepest test in Eddy County and several miles from any production. The formation may be Pennsylvania or Ordivician.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	Indiana	.85-1.25
Texas		Ohio	
North Central	.97-1.25	Lima	1.50-1.60
Panhandle	.70-1.12		
West Texas	.80-1.27	Michigan	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.30
Arkansas	.94-1.36	Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

		ACTUAL PRODUCTION		
	*P.A.W. Recommendations April	Week ended Apr. 22 1944	Week ended Mar. 25 1944	Week ended Apr. 24 1943
Oklahoma	328,000	335,550	329,500	341,450
Kansas	285,000	263,800	274,100	318,800
Nebraska	1,000	1,200	1,350	2,200
Panhandle Texas	.....	91,100	92,850	91,000
North Texas	.....	143,850	142,600	134,950
West Texas	.....	374,000	340,900	214,450
East Central Texas	.....	127,250	116,600	99,700
East Texas	.....	362,300	365,100	319,800
Southwest Texas	.....	293,050	291,500	188,500
Coastal Texas	.....	518,800	513,800	340,750
TOTAL TEXAS	1,916,000	1,910,350	1,863,350	1,389,150
North Louisiana	.....	76,150	76,150	88,400
Coastal Louisiana	.....	282,500	283,950	257,900
TOTAL LA.	347,700	358,650	360,100	346,300
Arkansas	76,700	79,550	79,650	72,200
Mississippi	45,000	42,850	41,500	53,650
Alabama	.....	100	50	.....
Florida	.....	50	50	.....
Illinois	215,000	201,700	216,450	225,250
Indiana	13,600	13,850	13,600	12,300
Eastern	72,400	72,500	69,000	75,700
Kentucky	23,000	24,350	22,400	21,150
Michigan	53,000	48,500	50,950	57,100
Wyoming	93,000	98,700	91,350	92,300
Montana	24,000	21,500	20,800	20,250
Colorado	7,000	8,200	8,200	6,850
New Mexico	111,700	112,050	112,850	97,250
TOTAL EAST OF CALIF.	3,612,100	3,593,450	3,555,250	3,131,900
California	829,400	833,900	829,500	780,700
TOTAL U. S.	4,441,500	4,427,350	4,384,750	3,912,600

*P.A.W. recommendations and state allowables, as shown above, represent the production of crude oil only, and do not include amounts of condensate and natural gas derivatives to be produced.

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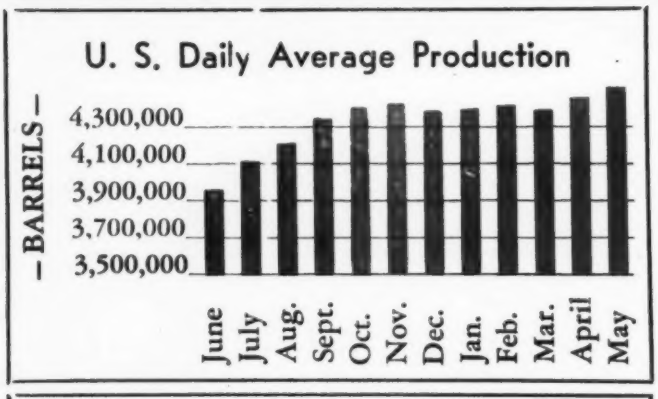
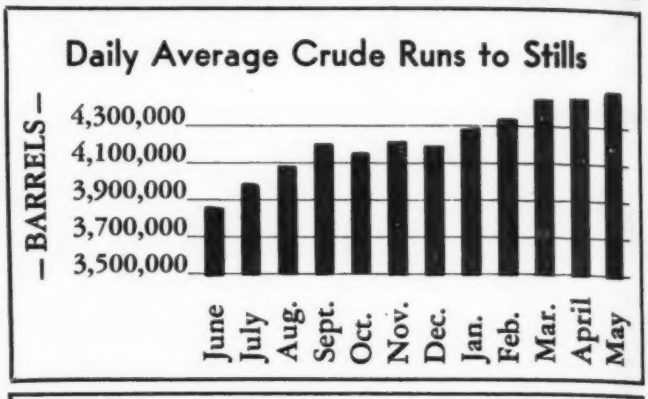
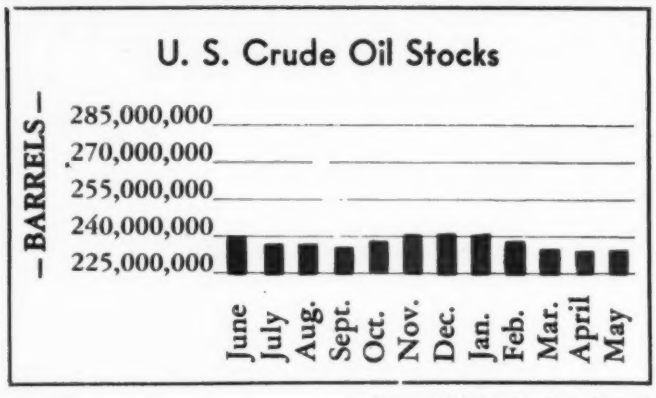
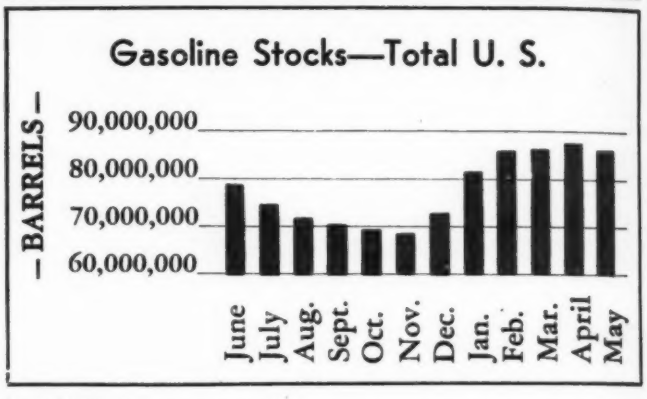
PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

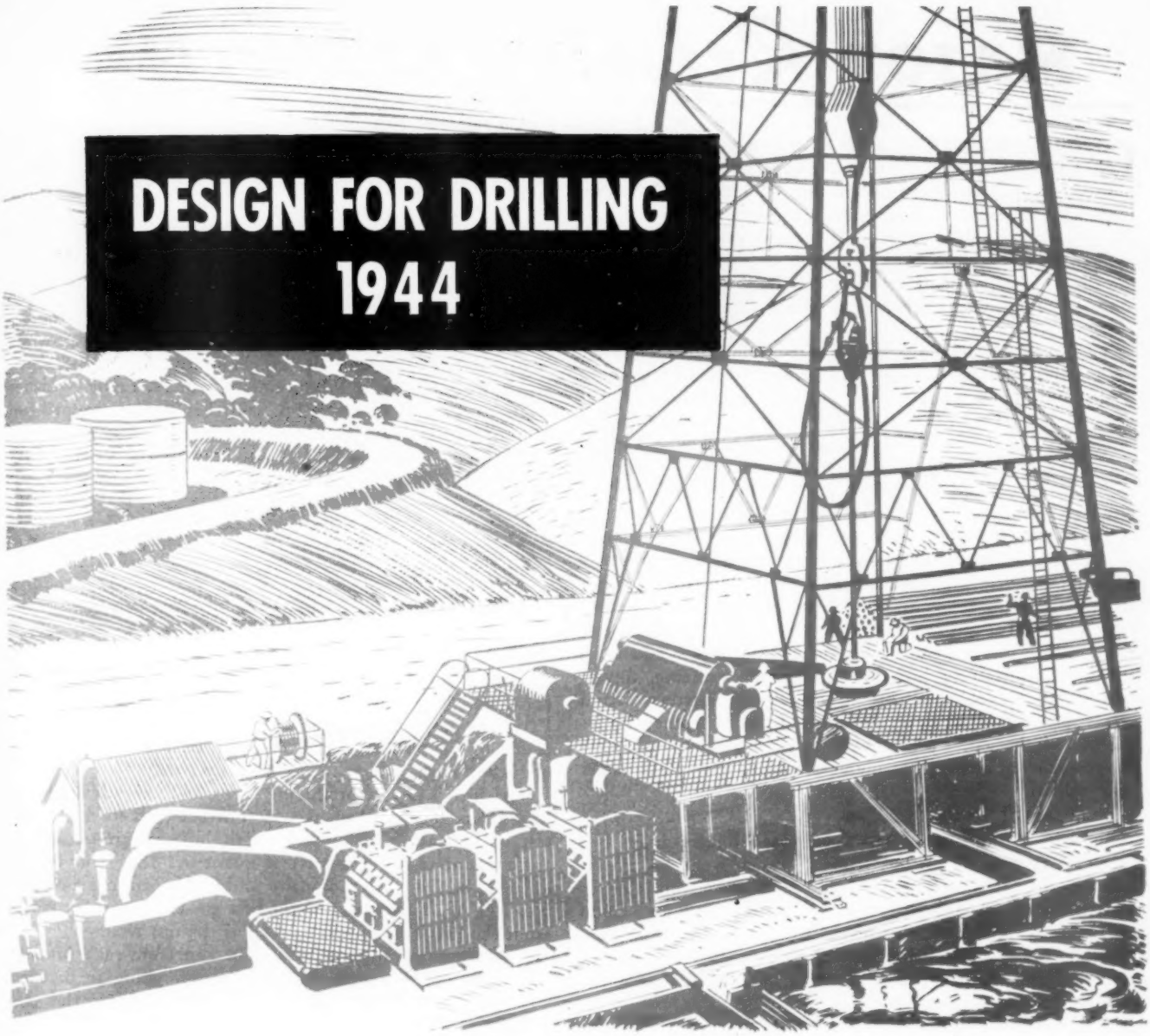
Summarized Operations in Active Fields for May, 1944

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
Eastern Texas	27	11	19	26	3500-4700	2&	40	Rotary
Gaines County	36	21	3	....	4400-5584	2&	22-35	Rotary
Hockley County	16	14	9	....	4800-6850	2&	20-30	Rotary
Ector County	21	9	11	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	18	14	7	....	1700-3900	2&	40	Rot.-Cab.
Nueces County	13	11	11	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	17	3	5	....	3730-3935	2&	42-43	Rot.-Cab.
Hawkins Field	9	4	7	13	4495-4912	2&	19-29	Rotary
Oklahoma								
Okfuskee County	12	7	7	....	2150-4125	2 or 3	38	Rotary
Kansas								
Russell County	15	5	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	6	3	4	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	10	6	5	....	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	90	21	101	110	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	6	2	3	....	3150-4030	2	30-34	Rot.-Cab.
California								
Kern County	25	7	10	14	1840-11,450	2 or 4	14-20	Rotary
Wilmington County	11	6	10	13	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1944

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1943 (bbl.)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	14	18	9	10	11	16	9	7	18	13	27,605,000
California	67	97	31	70	59	60	29	30	16	21	284,415,000
Illinois	43	88	50	76	79	81	88	90	122	103	81,070,000
Indiana	8	20	10	18	33	26	10	6	16	14	5,320,000
Kansas	82	141	60	103	52	50	30	23	25	14	105,780,000
Kentucky	23	38	28	27	21	15	....	....	10	....	7,890,000
Louisiana	40	46	26	36	21	24	16	10	....	16	125,904,000
Michigan	24	53	18	46	20	31	....	11	20	13	20,576,000
Mississippi	6	6	2	4	....	....	10	....	16	....	18,845,000
Montana	4	12	8	5	....	....	9	5	....	....	7,598,000
Nebraska	1	....	2	....	....	3	....	....	4	....	&791,000
New Mexico	15	23	11	13	9	11	....	....	12	....	38,955,000
New York	70*	96*	85*	88*	58	49	15	24	....	....	4,783,000
Ohio	29	57	28	45	28	30	14	19	50	....	3,220,000
Oklahoma	95	118	44	97	41	44	....	....	43	46	120,880,000
Pennsylvania	188*	207*	80	183	161	149	....	....	....	....	15,986,000
Texas	202	228	201	250	311	294	210	240	301	290	588,560,000
West Virginia	76	54	51	43	12	22	3	3	14	15	3,256,000
Wyoming	4	6	4	3	1	4	6	3	5	13	34,686,000
Total	951	1398	748	1117	925	898	449	471	672	558	1,496,120,000

*Includes water-intake and pressure wells.



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MAJOR *Refining* ACTIVITIES

CITIES SERVICE COMPANY'S vast new refinery at Lake Charles, Louisiana, recently opened, was designed, engineered, and constructed by the M. W. Kellogg Company. Built specifically for production of 100-octane aviation gasoline, it will supply a substantial percentage of the gasoline used to fuel American planes throughout the world. Following the approval of the Petroleum Administration for War on March 7, 1942, Cities Service engaged Kellogg for the entire task.

The work involved the conversion of one square mile of solid forest into a habitable site. Seventy tons of dynamite were needed to cut down trees and level the ground. Roads were built and railroads laid, and a drainage system constructed. A whole community of temporary buildings, including utilities, had to be erected before the site was ready for the construction of the plant itself. At the peak of the project the number of workers totaled 11,000.

This is the first completely new refinery of major size built in 20 years. Starting from scratch, the designer constructors were able to utilize all the newest facilities coordinated in a centralized plan, achieving maximum efficiency and production. The project embraces 18 major structures including three of the world's largest fluid catalytic cracking units, and units for topping, desalting, butane, isomerization, treating, alkylation and many others, all fitting into a single pattern with a power plant that services the entire refinery. Some idea of the size of the whole project may be gained in the fact that the power plant alone has enough capacity for a city of quarter of a million.

Sinclair Refining Company's six case Houdry fixed bed catalytic cracker at Corpus Christi, Texas, went on stream last month. The unit charges a gas oil derived from Corpus Christi crude and has a charge stock capacity of about 11,000 bbl. per stream day. It was originally designed for the Terminal Refining Corporation, which undertook its construction as a DPC project. Late in 1942, Sinclair acquired the property and purchased all equity, investing its own capital in the completion and subsequent operation of the plant. Blending facilities are also installed for the production of finished aviation fuel.

Contract for the expansion of the Humble Oil and Refining Company's gasoline plant at Tomball, Texas, has been awarded the Gasoline Plant Construction Corporation. The project calls for revamping the present plant and installation of four compressors. Capacity of the plant will be increased to handle an additional 8,000,000 cu. ft. of gas a day. The project will cost about $400,000.

Phillips Petroleum Company and O. C. Field Gasoline Corporation are building a gasoline plant to process all the gas from the presently defined extent of the Fullerton field in Andrews County, Texas. It will be put into operation September 1. A large portion of the building material and equipment are being moved to the location from other properties of the two companies. Phillips will operate the plant for the partnership.

American manufacturers of carbon black, one of the materials whose scarcity is limiting the synthetic rubber program, have been asked to consider the building of plants in Russia and Iran by the War Production Board. H. Leroy Whitney, technical adviser to the WPB, said that large untapped supplies of natural gas, from which carbon black is made, were to be found in Russia and at the head of the Persian Gulf. Transportation facilities are available, he said.

A new oil refinery has been constructed in Ust Ukhta (Chichibu) in the Soviet Union, center of the extensive Petchora coal region, the foreign press reports. The refinery has an annual capacity of some 5,000,000 metric tons of crude oil.

A $2,000,000 natural gasoline and cycling plant will be constructed for the Haynesville Pettit lime pool of Claiborne Parish in northern Louisiana. The plant will be built in the center of the pool on the H. P. Camp farm 3 miles northwest of Haynesville.

The field has 161 producing wells and extends across the state boundary into Arkansas. A contract calls for a thorough test of formations below the Pettit lime and if oil and gas are encountered in commercial quantities they will be produced. The Ohio Oil Company and Gulf Refining Company No. 1 G. W. Taylor, one of the best gas-condensate producers from the Pettit lime, will be used as the test well.

The program calls for lines to be run from each producer to the gasoline plant so that all gas now going to flare will be saved. After the gasoline has been extracted it will then be returned to some strata in the pool. There are approximately 13,000 acres in the area with wells spaced one well to 80 acres. Twenty companies have holdings in the pool. Each will operate its own wells for the unitization will not affect the operation.

A natural gasoline plant will be constructed by the Shell Oil Company, Inc., to serve the union pool in Andrews and Gaines counties, Texas. Applications to PAW and WPB are said to be acceptable. The new plant will have a high butane extraction efficiency. It will serve Shell's extensive lease holdings in that area and also other operators who have producing wells.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels

Week ended May 29, 1944

A.P.I. Figures

(Figures in thousands of bbl. 42 gal. each)

DISTRICT	DAILY REFINING CAPACITY Potential rate	DAILY REFINING CAPACITY Per cent reporting	CRUDE RUNS TO STILLS Daily average	CRUDE RUNS TO STILLS Per cent operated	Total production[3]	Total stocks[3]
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	2,518	90.3	2,410	95.7	14,897	73,957
Appalachian—						
District No. 1	130	83.9	102	78.5	532	3,395
District No. 2	47	87.2	59	125.5	318	1,780
Ind., Ill., Ky.	824	85.2	752	91.3	4,625	28,280
Okla., Kans., Mo.	418	80.2	363	86.8	2,289	11,280
Rocky Mt.—						
District No. 3	8	26.9	13	162.5	78	117
District No. 4	141	58.3	94	66.7	641	3,251
California	817	89.9	739	90.5	4,974	53,954
TOTAL U. S.— May 27, 1944	4,903	87.3	4,532	92.4	28,354	176,011
TOTAL U. S.— May 20, 1944	4,903	87.3	4,483	91.4	28,364	176,627
U. S.— May 29, 1943	.....	.....	3,671	.....	23,527	188,960

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; kerosine, gas, and distillate fuel oil, and residual fuel oil.

[2]Stocks at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; kerosine, gas oil, and distillate fuel, and residual fuel oil.

[3]Figures on production and stock include reported totals plus an estimate of unreported amounts and are on a Bureau of Mines basis.

P 762.1

THE Petroleum Engineer

JUNE, 1944

Steam Generation, Utilization, and Balance at Butadiene Plant

☆ Superheaters raise steam to more than 1000° F. in Port Neches plant

PETROLEUM ENGINEER Exclusive Feature

by Fred Kraus, Process Engineer
and
H. R. Davis, Job Engineer
The Lummus Company

THE Port Neches, Texas, plant of the Neches Butane Products Company is designed for the production of butadiene at the rate of 100,000 tons per year by dehydrogenation of a butane-butylene (B-B) charge. When combined with styrene, in the two adjoining copolymerization plants, this output of butadiene is sufficient to make 110,000 long tons of GR-S synthetic rubber, which approximates one-seventh of the United States wartime synthetic rubber program. Thus, the Neches plant is rated as the largest of its kind in the world. It was designed and built by The Lummus Company.

Because of the Neches plant's spectacular size and tremendous capacity, it has many features of interest to the petroleum engineer. Among these is its steam plant, which supplies steam for heating all reboilers except that reboiler heat obtained by heat exchange from circulating hot solvent and oil streams; process steam for stripping; steam for pump and compressor drive, and the dilution steam required by the reactors.

Although these are the uses of steam at the Neches plant, the principal points of interest are: (1) The steam plant and the steam balance; (2) the continuous use of steam through 3 systems from 450 lb. per sq. in. gauge[1] to 150 lb. and, finally, to 15 lb. and its effective economical use at each pressure; (3) the process requirement for steam superheated to more than 1000° F.—a temperature considerably higher than that heretofore employed in industry—and the features of the superheaters required to raise steam from 366°F. at 150 lb. to that high temperature level; (4) the exclusive use of steam for pump and compressor drive, and (5) the economics involved.

[1]All pressures in this article are given in lb. per sq. in. gauge unless otherwise stated.

The Steam Plant

The boiler feedwater makeup consists of 2,620,000 lb. per hr. of water and steam of which 1,700,000 lb. is Amberlite-treated water pumped at a pressure of approximately 50 lb. into two Worthington deaerating feedwater heaters that also receive 1,300,000 lb. per hr. of condensate returned from reboilers in the process area, and 150,000 lb. per hr. of steam from the 15-lb. system.

The deaerating feedwater heaters are of the horizontal, double-element, double-shell type and each is designed for 600,000 lb. per hr. of treated water at 60 to 90° F., 900,000 lb. per hr. of condensate from the reboilers at 288° F., and 75,000 lb. per hr. of steam at a pressure ranging from 3 to 15 lb. per sq. in. saturated. Feedwater out of the deaerating heaters contains less than 0.005 cc. of oxygen per liter (Winkler).

Of the 2,620,000 lb. per hr. of boiler feedwater, 2,300,000 lb. is pumped to boilers, the remaining 320,000 lb. being pumped to waste heat boilers. Eight Ingersoll-Rand, type No. 5, HMT, 4-stage, horizontally split, diffuser-type centrifugal pumps, each of which has a capacity of 600,000 lb. per hr. at a discharge pressure of 650 lb., feed gas-fired boilers and the waste heat boilers. Each boiler feed pump is driven by a type DOR, 125 General Electric single-stage turbine operating at a throttle pressure of 450 lb. of saturated steam and discharging at 160 lb.

The boiler plant is the largest outdoor installation in the country. Except the control panels, everything is out-

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Big Tide of Exploration Held Back by Shortages

Search for oil, it is reasonable to believe, would be record breaking indeed if strict limitations in materials and equipment, manpower, and price were not in force. Despite these obstacles a wave of exploration is hitting the country and wildcatters are said to be spending something like $300,000,000 this year to gain new petroleum sources.

The Gulf Coast is the inspiration for the bulk of the new operations. Discoveries in Alabama and Florida, the big new producer in Mississippi, Georgia activity, and survey work that reaches through both Carolinas—all these testify to intense and extensive interest on the part of operators.

Instead of the 200 or 300 new tests that might have resulted in Mississippi, however, only 40 have been planned. This gives a reasonable gauge to indicate the difference made by war regulations and price ceilings. With these impediments cleared the country might well look forward to the greatest tide of discovery yet seen.

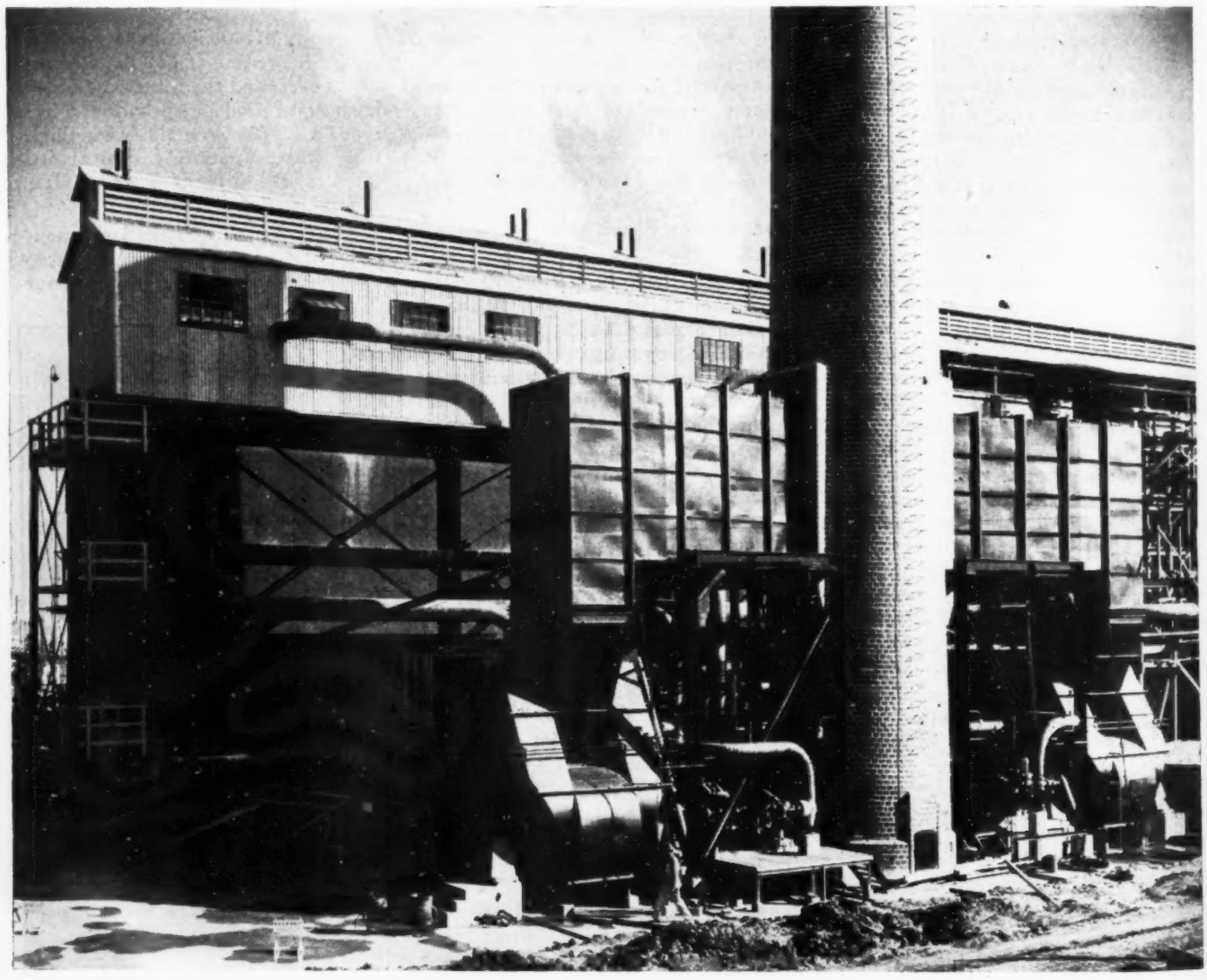
doors. Steam is generated in 4 Babcock and Wilcox boilers each rated at 525,000 lb. per hr. at 500 lb. dry and saturated. Their combined output is 2,100,000 lb. per hr. at that pressure. All boilers are gas-fired and one is equipped with 4 auxiliary oil atomizers to burn a small amount of the excess heavy fuel oil produced in the Neches plant. When oil-fired, fuel oil is fed by a rotary fuel pump rated at 10,500 lb. per hr. at a discharge pressure of 300 lb. per sq. in. to 4 oil burners.

Ten 24½-in. Babcock and Wilcox forced-draft, circular, register-type gas burners are installed in each boiler and each requires approximately 744,000 cu. ft. per hr. of gas having a net heating value of 880 B.t.u. per cu. ft. The heating surface, per boiler, is 50,179 sq. ft. or a total of 200,716 sq. ft. of heating surface in the four boilers.

Each boiler is equipped with a steam drum measuring 60 in. diam. by 45 ft. long and a 42 in. diam. by 39 ft. long bottom drum. There are six 7¼-in. square upper sidewall headers, two 11¾-in. O. D. lower sidewall headers, and one 7¼-in. square front wall header per boiler. The number of tubes installed in each boiler and their diameters are:

No. of tubes	Size of tubes
225 boiler tubes	3¼ in.
1782 boiler tubes	2½ in.
426 wall, roof and floor tubes	varying dimensions

One part of the steam plant showing the forced draft installation in the foreground and one of the boilers in the background



Each boiler is equipped with an air preheater having a heating surface of 20,300 sq. ft., a turbine-driven forced-draft fan handling combustion air at a pressure of 9.4 in. of water at 80° F., and a turbine-driven induced-draft fan handling flue gas at 5.8 in. of water at 425° F. There are two radial, brick chimneys rising 85 ft. above their foundations, their maximum O. D. measuring 16 ft. 7¾ in. A fuel oil storage tank, compressor building, and control house are included in the installation.

The compressor building houses a 975-cu. ft. per min., 125-lb. discharge pressure air compressor installed to provide compressed air for tube cleaning and the compressed air requirements of the process area, and two instrument air compressors that supply air for the boiler plant instruments at 89 cu. ft. per min. at an 80-lb. discharge pressure.

Automatic feedwater and combustion control. Water feed to each boiler is controlled by an automatic valve in the feedwater discharge piping to each boiler. The control is of the 3-element type in which the flow is controlled by the water-steam flow ratio and readjusted by the water level in the steam drum. The water flow-steam flow and water level for each boiler are recorded on the boiler control board in the control house.

The combustion control is designed to maintain constant steam pressure in the main header, correct fuel-air ratio, and correct furnace draft on each boiler. The master pressure recorder-controller sets up an air flow by controlling the speed of each forced- and induced-draft fan and by positioning the induced-draft dampers. Should this cause a change in furnace draft, the furnace draft controllers will correct the condition by positioning the forced-draft fan dampers.

A change in air flow through the air flow-fuel flow ratio controller, one of which is installed in each boiler, will position the fuel valves to maintain the correct fuel ratio. The correctness of this ratio is shown by coincidence of the steam flow-air flow pens of the Bailey boiler meters mounted on the individual boiler panels. Provision is made for remote manual control from the boiler control board. This also permits base loading of boilers or operating them as a unit as desired.

Steam balance, flow and utilization. Although charged with a butane-butylene mixture, obtained by processing petroleum and its products, the Neches plant essentially is a chemical plant and as such its requirements for steam, the factors governing development of its steam balance, and its steam utilizations differ somewhat from those of the petroleum refinery. This difference is found in the requirement for extremely high temperature steam, in considerable volume, and for dilution of gases in the dehydrogenation reactors.

In establishing the plant's total steam requirements, the governing factors were: (1) The reboiler requirements in terms of quantity and pressure; (2) the superheated steam requirements of the dehydrogenation reactors, and (3) the requirements of steam for pump and compressor drive. Once this total was determined, the objective was to develop a steam balance assuring the maximum of that total efficiently applied to use with the minimum vented to atmosphere. Table 1 details the steam balance developed.

The 450-lb. system. The total boiler output of 2,100,000 lb. per hr. of 450-lb. steam goes to the 450-lb. system.

Of this total 530,000 lb. per hr. is required for boiler feed pumps and fans, 440,000 lb. per hr. goes to the 2000-hp. dehydrogenation plant gas compressors, 500,000 lb. per hr. to the cooling water pumps, and 230,000 lb. per hr. to the cold acid plant emulsion pumps. These units exhaust to the 150-lb. system.

A total of 50,000 lb. of 450-lb. steam drives the fresh water and treated water pumps and exhausts to the 15-lb. system.

The turbines and compressors using 450-lb. steam exhaust at 150 lb. total approximately 1,700,000 lb. per hr. of which 70,000 lb. per hr. is allowable moisture. This moisture is trapped out and recovered in the high pressure condensate drum. The net amount of dry steam from the 450-lb. system turbines to the 150-lb. system is 1,630,000 lb. per hr. In addition a total of 340,000 lb. per hr. of 450-lb. steam goes to the 150-lb. system through pressure reducing valves. The plant reboilers take 10,000 lb. per hr. from the 450-lb. system, which is condensed and goes to the high pressure condensate drum.

The 150-lb. system. The 150-lb. system requires a total of 2,270,000 lb. per hr. of which 340,000 lb. per hr. through pressure reducing valves is the makeup; the steam from the waste heat boilers is not controllable; 1,630,000 lb. per hr. is the net dry steam exhausted from the 450-lb. system, and 300,000 lb. per hr. is received as makeup from the waste heat boilers.

There are 12 Babcock and Wilcox horizontal, gas-tube, 200-lb. per sq. in. design pressure waste heat boilers. Their total output is 300,000 lb. per hr. of steam at 150 lb. per sq. in. gauge and 20,000 lb. per hr. of blowdown. Each contains a total of 13,000 sq. ft. of heating surface and all are served by effluent gas from the dehydrogenation plant reactors.

Superheaters. A total of 845,000 lb. per hr. of steam from the 150-lb. system is fed to the plant's 6 Babcock and Wilcox superheaters, which are an outstanding feature of the installation. As has been stated, the superheaters heat steam from a temperature of 366° F. at a pressure of 150 lb. to more than 1000° F. at 50 lb. for dilution of gases in the dehydrogenation reactors.

The superheaters are gas fired. Each has 4 Babcock and Wilcox forced-draft circular register-type gas burners and each uses 46,000 cu. ft. per hr. of gas with a net heating value of 940 B.t.u. Each contains 15,773 sq. ft. of heating surface. There is one air preheater per superheater and each of these contains 7360 sq. ft. of heating surface. Each air preheater is equipped with a turbine-driven, forced-draft fan that handles 86,000 lb. of combustion air at a pressure of 6.6 in. of water and 80° F., and one turbine-driven induced-draft

TABLE 1

Steam balance at Port Neches plant of Neches Butane Products Company

	Make per hr., lb.	Use per hr., lb.
Water		
Makeup treated feedwater	1,170,000	
Condensate	1,300,000	
15-lb. steam	150,000	
To boiler		*2,300,000
To waste heat boiler		†320,000
450-lb. system	2,620,000	2,620,000
Boiler plant feedwater pump and fan turbines		530,000
Gas compressors		440,000
Cooling water pumps		500,000
Emulsion pumps		230,000
Fresh water and treated water pumps		50,000
Reboilers		10,000
Pressure reducing valves		340,000
Boiler output	2,100,000	
150-lb. system	2,100,000	2,100,000
From 450-lb. system through turbines	1,630,000	
From 450-lb. system through pressure reducing valves	340,000	
Wasteheat boilers	300,000	
Superheaters		845,000
Reactors		45,000
Superheater fans		80,000
Reboilers		820,000
Process pumps		400,000
Stripping in process		40,000
Refrigeration unit turbines		30,000
Direct acting pumps and air compressors		10,000
15-lb. system	2,270,000	2,270,000
From 450-lb. and 150-lb. system through turbines	510,000	
From high pressure condensate drum	60,000	
Reboilers		400,000
Refrigeration unit turbines		10,000
Deaerating feedwater heater		150,000
Waste to atmosphere		10,000
Condensate	570,000	570,000
450-lb. reboilers	10,000	
150-lb. reboilers	820,000	
15-lb. reboilers	400,000	
Turbine moisture trap-out:		
From 150-lb. exhaust	70,000	
From 15-lb. exhaust	20,000	
Steam flashed off to 15-lb. system		60,000
Condensate to deaerating heater		1,300,000
Refrigeration unit turbines	40,000	
	1,360,000	1,360,000

*Blowdown = 200,000 lb. per hr.
†Blowdown = 20,000 lb. per hr.

fan handling 223,000 lb. per hr. of flue gas at a pressure of 6.1 in. of water and 730° F.

The superheaters have 2-in. O. D. steel and alloy tubing of various specifications made necessary by the fact that as temperature rises different alloys are required to meet conditions.

An important feature of the design of the superheaters is recirculation of flue gases to control the temperature of the gases impinging on the superheater tubes so as not to exceed the allowable temperature on the tubes. To accomplish this, the induced-draft fan picks up the flue gases leaving the superheater and blows a part of them through the air preheater to atmosphere. The balance of the flue gases are returned to the furnace and mixed with the products of combustion at the superheater inlet to increase the gas mass flow across the superheater and to decrease the temperature of the gases entering the superheater.

The 150-lb. system also supplies 45,000 lb. per hr. of steam to the dehydrogenation reactors for regeneration. A total of 40,000 lb. per hr. from the 150-lb. system is used for process stripping. Reboilers receive 820,000 lb. per hr. of steam, which is condensed and flows to the high pressure condensate drum. A total of 30,000 lb. per hr. is used to drive a refrigeration unit condensing-turbine. As condensate the steam goes to the low pressure condensate drum. Process pumps require 400,000 lb. of 150-lb. steam for drive and this exhausts to the 15-lb. system. A total of 10,000 lb. per hr. of 150-lb. steam is used for driving direct-acting process pumps and, because lubricating oil from the direct-acting pumps is entrained, the exhaust steam cannot be used further without special treatment; thus it exhausts to atmosphere.

The 15-lb. system. The turbines of the 450-lb. and 150-lb. systems, which exhaust to the 15-lb. system, exhaust a total of 530,000 lb. per hr. of steam, 20,000 lb. of which is allowable moisture. This is trapped out and recovered. The net amount of dry steam is 510,000 lb. per hr. In addition, 60,000 lb. per hr. of 15-lb. steam is released from the high pressure condensate drum to the 15-lb. system. Reboilers take 400,000 lb. per hr. and this is condensed and goes to the low pressure condensate drum. Also condensed and sent to the low pressure condensate drum after use is a total of 10,000 lb. per hr. used to drive a refrigeration unit condensing-turbine in the cold acid plant. The deaerating feedwater heater receives 150,000 lb. per hr., as previously mentioned. The balance, 10,000 lb. per hr., goes to atmosphere from the 15-lb. system.

From the totals shown, a steam balance of exceptionally high efficiency has been obtained. Of the 2,100,000 lb. per hr. of 450-lb. steam, 84 per cent is usefully employed for driving and only 16 per cent is bled through pressure reducing valves and fed to the 150-lb. system. All 150-lb. steam is applied to drives, reboilers, and process and none is bled down through pressure reducing valves to the 15-lb. system. In the 15-lb. system, 98 per cent of the steam is applied to drives and reboilers with but 2 per cent going to atmosphere as waste.

Condensate. For the handling of condensate, there are two condensate drums, 1 high pressure and 1 low pressure. As noted, steam is flashed off the high pressure drum to the 15-lb. system. Condensate is returned to the deaerating heaters from both drums in a common line. Steam recovered as condensate from all 3 systems totals 1,300,000 lb. per hr. as follows: From the 450-lb. reboilers, 10,000 lb. per hr.; 150-lb. reboilers, 820,000 lb. per hr.; 15-lb. reboilers, 400,000 lb. per hr; turbine moisture trap from 150-lb. and 15-lb. systems, 90,000 lb. per hr., and refrigeration unit turbines, 40,000 lb. per hr. Of the total, 60,000 lb. per hr. of 15-lb. steam is flashed off the high pressure condensate drum to the 15-lb. system.

Economics. The Neches plant requires steam in considerable volume and at relatively low pressure. As this steam can be used for pump and compressor drive, before using it for processing, it was decided to use steam exclusively for these drives. A total of 20,000 kw. per hr. would have been required and the decision to use steam not only resulted in a substantial saving of critical material and equipment, but it made possible the saving of the investment in such material with the net result that the ultimate cost per gallon of the plant's production is lower.

The use of steam at 450 lb. for pump and compressor drive and its subsequent use for processing and drive at the lower pressure likewise exerted an influence because it is more economical to make steam at 450 lb. and bleed it down than to make 150-lb. steam directly. Although, at the higher pressure, the wall of the steam drum has to be thicker to compensate for the greater pressures, this is offset by the fact that, at the lower pressure, equipment larger in volume would have been required, and larger headers and steam piping of greater diameter would have been needed.

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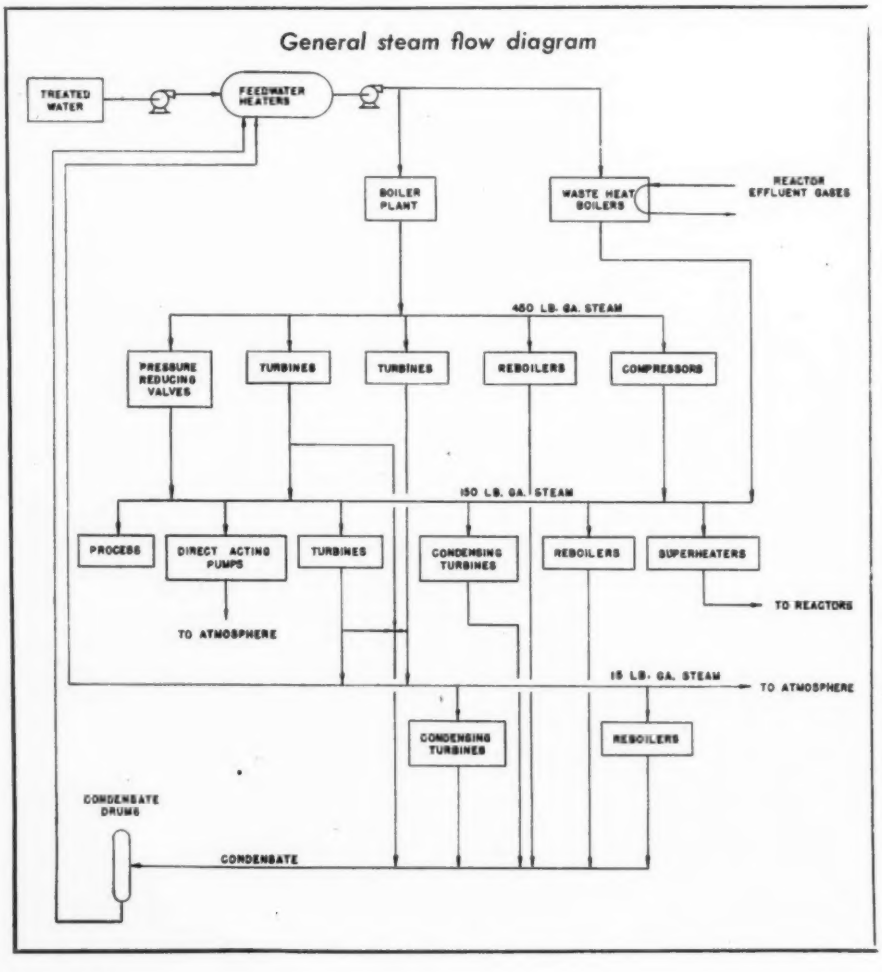
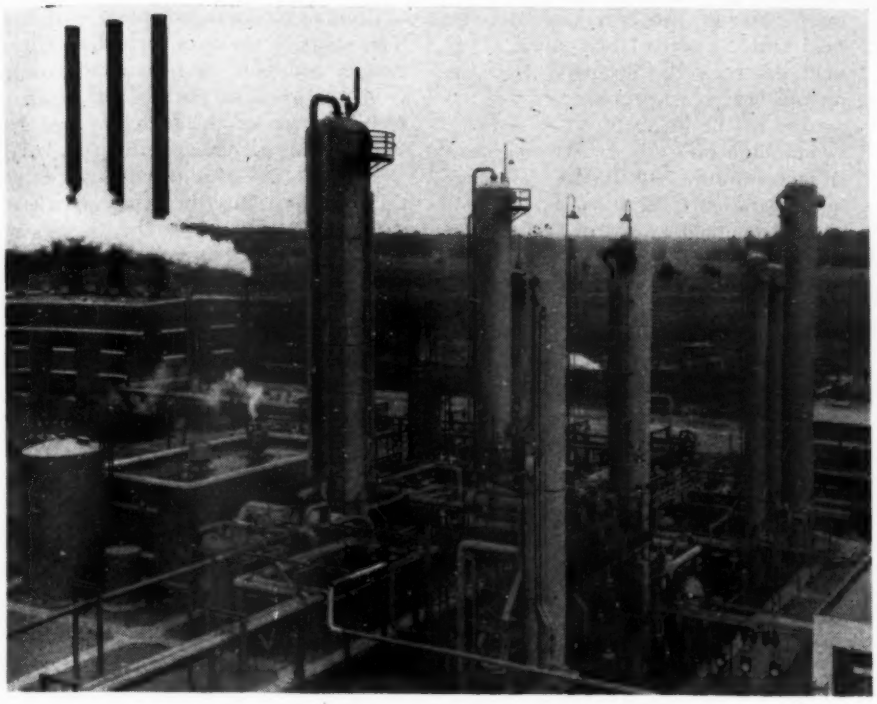
General steam flow diagram





Desulphurization plant, left foreground. Gasoline plant, center and right. Boiler house, left background

PETROLEUM ENGINEER Exclusive Feature

by

Frank H. Love

Managing Editor

Desulphurization of Gas in the McKamie Field, Arkansas

☆ **Sour gas made into usable fuel—Liquid hydrocarbons recovered in commercial quantities**

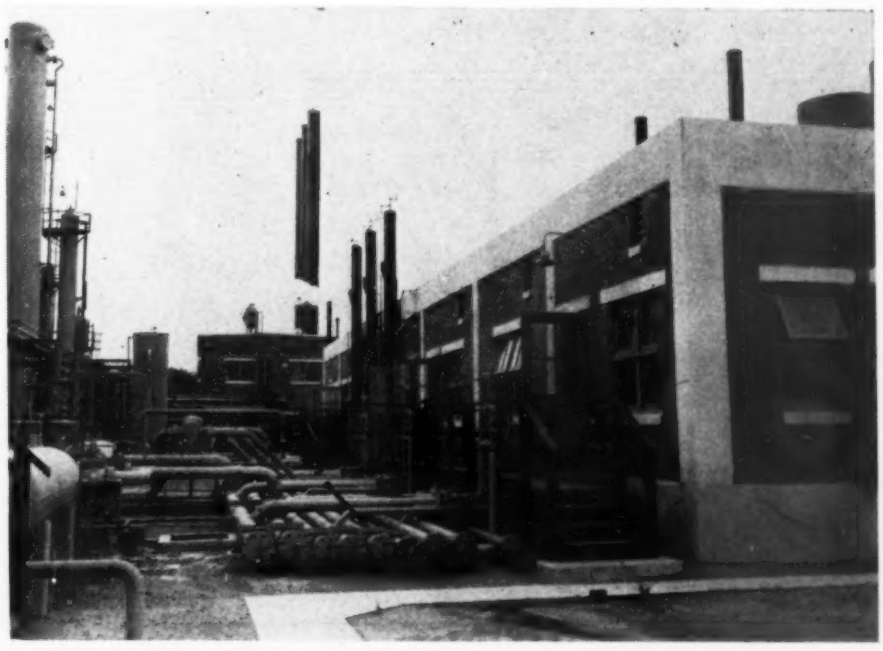
THE latest plant to be placed in operation in southern Arkansas for removal of hydrogen sulphide and carbon dioxide from the extremely sour gas of that area is that of the McKamie Gas Cleaning Company, located about 8 miles south of Stamps.

McKamie Gas Cleaning Company, an Arkansas corporation, is owned jointly by the Atlantic Refining Company and Standard Oil Company (New Jersey) and is operated by the latter.

Before arriving at a decision to make the installation a pilot plant was set up in the field to determine whether the gas could be successfully and economically purified. With this pilot plant gas containing 4250 grains of hydrogen sulphide per 100 standard cu. ft. was purified to an H_2S content of less than 0.05 grains per 100 standard cu. ft. The result proving satisfactory a plant designed to process approximately 25,000,000 cu. ft. of gas per day was constructed and has recently been placed in operation.

In addition to removing hydrogen sulphide and carbon dioxide from the gas, thus making it of use as a commercial fuel, various liquid hydrocarbons are recovered in commercial quantities. There include natural gasoline, isobutane, and normal butane. The propane extracted is used in the plant as boiler fuel.

The source of gas is 18 wells, which comprise the McKamie field. The Atlantic Refining Company owns 8 of



Exterior of compressor and absorption oil pump house

these wells, Carter Oil Company, a subsidiary of the Jersey Standard, owns 7, Barnsdall Oil Company, Frank Frankel et al, and Lion Oil Refining Company 1 each. Lion also has one well drilling on the extreme west side of the field, which has now reached a depth of approximately 8500 ft.

The McKamie field consists of about 3200 acres and wells are prorated according to the plant take. Each well is drilled in the center of 160 acres, this spacing having been established by the Arkansas Oil and Gas Commission prior to regulations by the Petroleum Administration for War. Production is from the top of the Smackover lime at a depth of approximately 9000 ft.

Both high and low pressure separators have been installed at each well, and three individual gathering lines extend from each well to the plant. One line takes gas from the high pressure separator, one from the low pressure separator, and one from tank batteries. At the present time gas is being taken only from the high and low pressure separators. Later, when certain minor details are worked out and the necessary equipment installed other than flowlines, gas will also be taken from the field tanks. Essential equipment in the field has been the installation of numerous heaters to prevent hydrate formation in the lines.

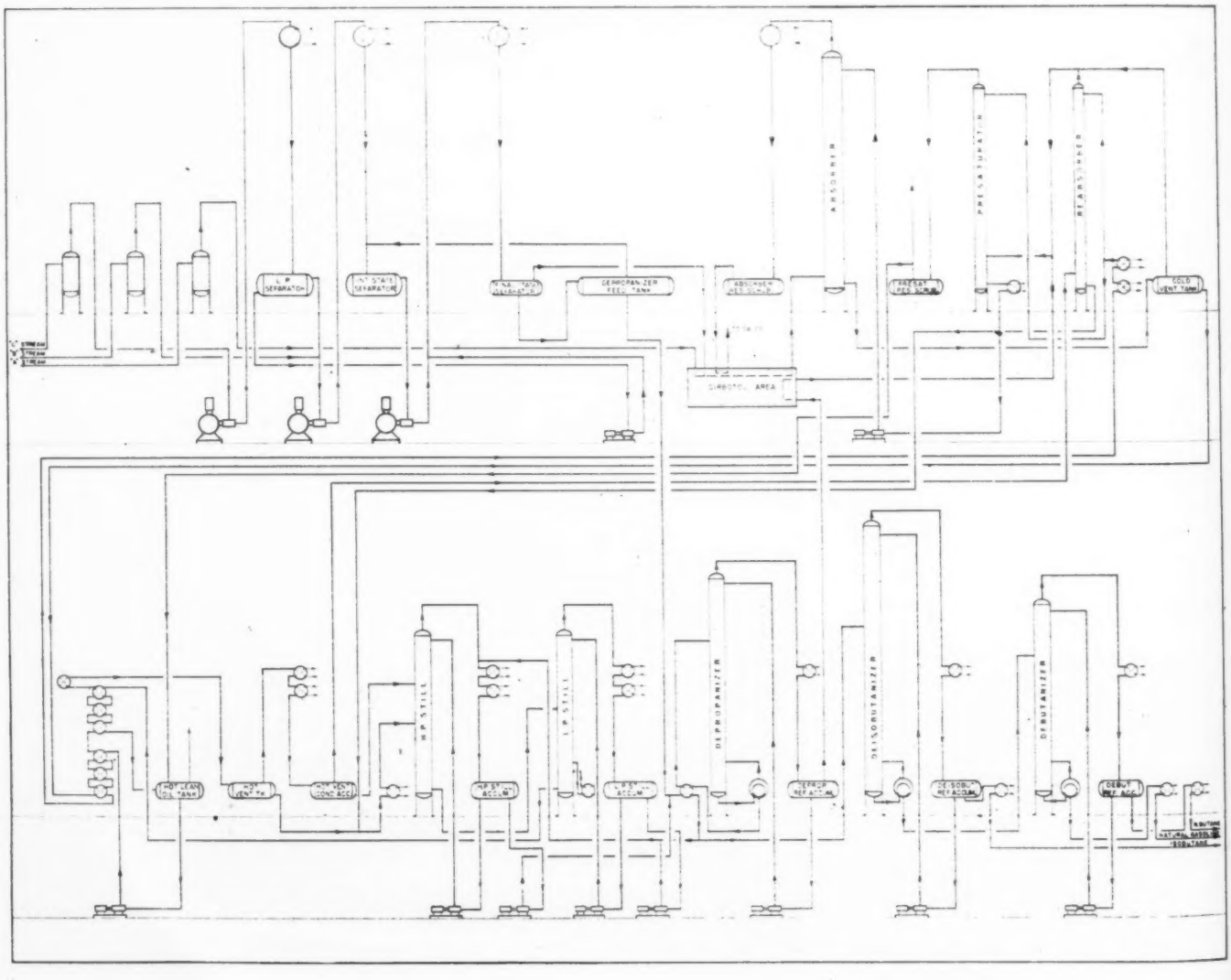
The high pressure separators operate at a pressure of 700 lb. abs., low pressure separators at 60 lb., and ½ lb. will be held on field tanks for recovery of vapors. Allowing for pressure drop, gas from the high pressure separators arrives at the plant at a pressure of 640 lb. and the low pressure gas at 40 lb. The high pressure gas goes directly into the line leading to an inlet scrubber and an absorber 6 ft. I. D. by 55 ft. The low pressure gas is compressed in three stages to a pressure of 640 lb., after which it is commingled with the high pressure gas stream ahead of the scrubber and absorber mentioned. The compressors are three 225-hp. V-type 3-stage units.

The united gas streams flow into the base of a high pressure absorber after being scrubbed, the absorber being operated at a pressure of 640 lb. per sq. in. gauge, then rises through the tower countercurrently to a 20-25 per cent solution of monoethanolamine. (MEA). This solution removes virtually all hydrogen sulphide and carbon dioxide from the gas. The purified gas is taken from the top of the high pressure absorber to the gasoline plant.

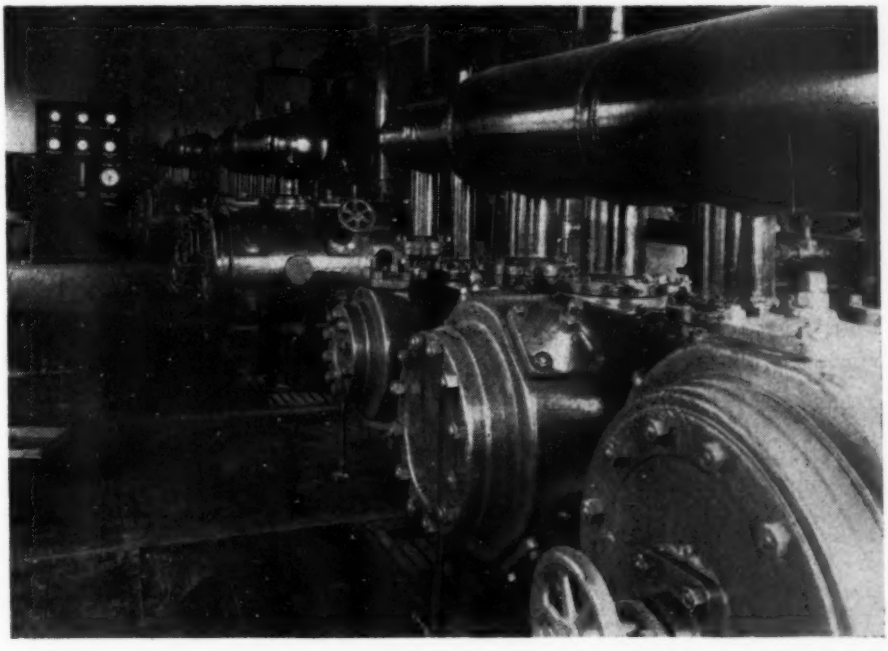
The rich MEA solution flows from the base of the absorber, through a heat exchanger to the top of the reactivator tower, the solution entering at a temperature of approximately 255° F. In the reactivator the temperature of the MEA solution is raised to approximately 285° F., which is sufficient to expel virtually all hydrogen sulphide and carbon dioxide. Heat for boiling in this column is supplied by exhaust steam from pump turbines, and a recording flow controller regulates the steam flow. Lean MEA solution flows through heat exchangers and coolers to the suction of two steam turbine driven centrifugal pumps, and is pumped through a flow control valve to the absorber to begin a new cycle.

The hydrogen sulphide and carbon dioxide stripped from the MEA solution in the reactivator, together with

Flow diagram of desulphurization, dehydration, and gasoline recovery plant



Interior of compressor room



steam generated in the boiling process, pass out the top of the column to a condenser where the steam is condensed and the hydrogen sulphide and carbon dioxide are cooled to approximately 100° F. The acid gas in amounts of 2,500,000 to 3,000,000 cu. ft. per day goes to the plant of the Southern Acid and Sulphur Company on the northeast corner of the plant site where approximately 50 to 60 tons of elemental sulphur are recovered daily. Condensate from the condenser flows to the MEA reflux accumulator and from there is pumped to the top of the reactivator column as reflux.

Gasoline Cycle

Purified gas from the desulphurization plant passes over to the gasoline extraction unit, in which are recovered propane, isobutane, normal butane, and natural gasoline.

The purified gas is contacted by mineral seal oil in an absorber after which it passes through a low pressure and a high pressure still. The overhead vapors then are discharged to the depropanizer column. This column is operated at a pressure of 350 lb. and on it is maintained a temperature of 128° F. The overhead, propane, after being sweetened and passed through the presaturator is used to fire the plant boilers, the bottoms going to the deisobutanizer, operated at 85-lb. pressure and 128° F. temperature. Isobutane taken from the top of the column is condensed and pumped to storage. Bottoms are discharged to the debutanizer, which is operated at a pressure of 70 lb. and a temperature of 133° F. The overhead from this column is normal butane and the bottoms 16-lb. RVP natural gasoline.

The depropanizer column is 42 in. I. D. and contains 10 trays on 18-in. spacing and 20 trays on 24-in. spacing. The deisobutanizer is of the same diameter but has 65 trays on 18-in. spacing. The debutanizer is 36 in. I. D. and contains 30 trays on 18-in. spacing.

Storage provided for the various products is as follows: Natural gasoline, one 3500-bbl. Hortonspheroid; isobutane, one 2000-bbl. Hortonsphere, and normal butane, one 3000-bbl. Hortonsphere.

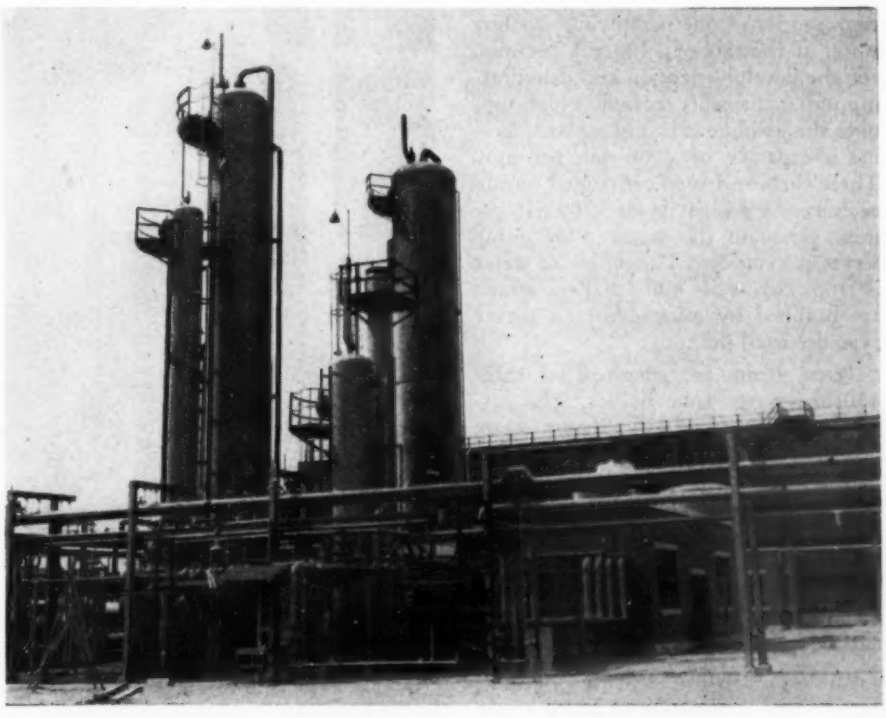
Dehydration Plant

When the purified gas passes from the desulphurization plant to the gasoline extraction plant the residue gas from the absorbers is discharged to the purification plant under a pressure of 600 lb. per sq. in. gauge and is passed through a dehydration and purification unit. In this cycle the residue gas first enters the base of an amine-glycol contactor, flowing upward through the tower countercurrently to the downward flow of amine-glycol solution. This removes a part of the water vapor and virtually all the remaining hydrogen sulphide and carbon dioxide from the gas. The dehydrated residue gas, having a dewpoint of about 35° below its flowing gas temperature, leaves through the top of the contactor at a pressure of approximately 600 lb. per sq. in., is metered, and enters the pipe line delivery system.

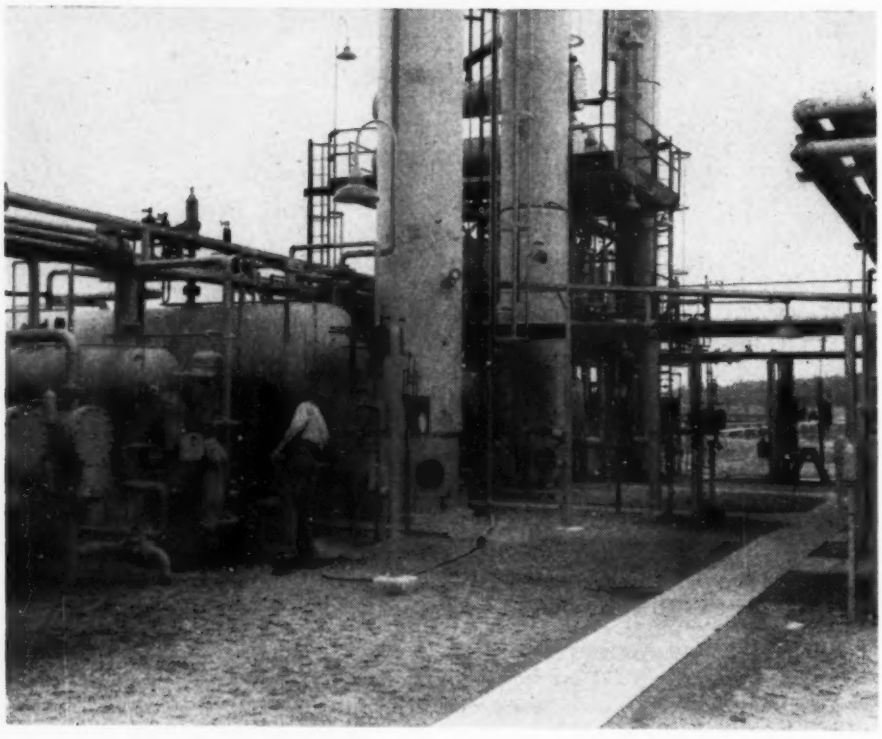
Lean amine-glycol solution circulates continuously through the contactor, entering near the top at a temperature of approximately 100° F. Rich solution flows from the bottom of the contactor, through heat exchangers, to an amine-glycol reactivator, which it enters near the top of the column at a temperature of approximately 245° F.

Flowing downward through the reactivator, the rich solution is further heated by steam rising through the column. Near the base of the reactivator the solution enters a reboiler where water is removed and leaves as a vapor through the top of the reactivator. Heat for boiling the solution is provided by steam condensing in a closed reboiler tube bundle. The reboiler temperature at the control point is about 280° F.

The reactivated amine-glycol solu-



Desulphurization and dehydration plants



Distillation side of gasoline plant showing depropanizer (left), deisobutanizer, and debutanizer

"A" stream

Component	*Mol per cent*
Nitrogen	12.00
Carbon dioxide	4.58
Hydrogen sulphide	6.80
Methane	86.15
Ethane	6.43
Propane	2.37
Isobutane	0.56
N-butane	0.66
Isopentane	0.23
N-pentane	0.13
N-hexane	0.11
Heptane	0.06
	100.00

"B" stream

Nitrogen	7.09
Carbon dioxide	4.31
Hydrogen sulphide	19.80
Methane	39.11
Ethane	14.29
Propane	8.91
Isobutane	2.24
N-butane	2.62
Isopentane	0.77
N-pentane	0.42
N-hexane	0.37
Heptane	0.07
	100.00

tion after first being cooled is ready for reuse in the contactor. To cool, the hot lean solution is discharged from the reactivator through a liquid level controller, then through a heat exchanger to a solution pump. The pump forces the solution through another heat exchanger and a cooler to the top of the contactor, completing the cycle. The solution pumps consist of two reciprocating units.

Water and Steam Systems

The cooling tower is of the aerator type, approximately 200 ft. long and 10 ft. wide. The tower is divided into two sections, one supplying cooling water at the rate of 3200 gal. per min. for the desulphurization and dehydrating units; the other section, which supplies the gasoline extraction plant, having a capacity of 2900 gal. per min. Three turbine driven centrigual pumps each having a capacity of 3200 gal. per min. circulate the water. One pump serves as a standby. The supply of water is from two wells 400 ft. deep, which are pumped by electric driven rotary type deepwell pumps.

Plant steam is generated by three 450-hp. water tube boilers. The system is a closed one, all exhaust steam being condensed and returned to the boilers as makeup.

Under normal operation plant recoveries are approximately as follows: Natural gasoline, 15,000 gal. per day; isobutane, 8,000 gal. per day, and normal butane, 9,000 gal. per day. The natural gasoline is sent by pipe line to the Baton Rouge refinery of the Standard Oil Company of Louisiana. Isobutane and normal butane are shipped to the same refinery but by tank car and for this purpose a 6-car loading rack has been built on the plant site. As mentioned, the propane recovered is used as boiler fuel.

Gas Analyses

The degree of sourness of the gas is revealed in the following analyses of the two streams, designated as the "A" and "B" streams.

Contractors

The Fluor Corporation, Ltd., Los Angeles, designed the gasoline extraction unit and had the labor contract for the entire plant. The desulphurization and dehydration units, known as the Girbotol process, were designed by the Girdler Corporation, Louisville, Kentucky.

—— ☆ ☆ ☆ ——

Interior of pump house

World's Deepest Oil Test*

☆ The story of Phillips Petroleum Company's Ada C. Price No. 1

by C. A. Daniels, Division Superintendent
Phillips Petroleum Company

AT the outset, I would like to point out that while Price No. 1 has received a great amount of publicity through various channels as the world's deepest well, it was not our anticipation to drill the well for the purpose of establishing records but, rather, to obtain a producing oil well. Our original and final objective was to thoroughly test the Ordovician formation, which has proved quite prolific in several areas of West Texas. We had expected to penetrate the Ellenberger at 8000 ft. to 8500 ft., which was the projected depth of the well, but since we did not reach the Ellenberger at the expected depth, due to thickening of the overlying beds, drilling was continued.

Contrary to most of the publicity that we received with regard to the establishment of various records "for the most of this" and "the greatest amount of that," etc., it is my thought that probably the record that was set was in the perseverance of our management in its determination to reach the final objective of testing the Ellenberger lime. The experience gained on this project proved conclusively that wells can be drilled to depths in excess of 15,000 ft. with present modern equipment of not any special design at a relatively high degree of efficiency. Furthermore, considerable valuable information with regard to drilling technique, equipment performance, and geological data was obtained.

For the successful completion of this project, we cannot overemphasize the credit due those directly associated with the actual work. Recognition for this splendid piece of work is therefore in order for our drilling crews, drilling and mud supervisors, and our West Texas production management and organization, as well as the many supply, equipment, and oil field service organization men.

General Data

Price No. 1 is located in the midst of a 25,000-acre block of leases about 40 miles southeast of Fort Stockton, in southeastern Pecos County. It is about 35 miles south of the APCO-Warner field where the Ellenberger producing horizon is reached at a level of 4600 ft. Location was staked on June 24, 1942 in Section 11, Block 101, TCRR Survey; ground elevation is 3250 ft. above sea level.

As no surface water was available in this area, it was necessary to drill a water well approximately 500 ft. deep, which was equipped with 4-in. tubing and an individual pumping unit. This well furnished ample water for all operations.

A cavernous limestone formation was present on the surface at the well location, extending to approximately 500 ft. in depth, and it was therefore deemed advisable to set surface pipe through this section with cable tools. The Pohland Drilling Company was employed, moving in a National machine, and on June 30, 1942, spudded in on Ada Price No. 1. A 24-in. hole was drilled and 26 days later, a depth of 520 ft. was reached. Then 20-in. 90-lb. L. W. casing was set at 507 ft., which point was below the cavernous lime section. This surface casing was cemented with 970 sacks of cement by conventional pump and plug method, but since no returns were obtained, an additional 300 sacks of cement were pumped behind the casing from the top, which completed filling the annular space to the bottom of the cellar. Cable tools were then moved out and rotary equipment was installed.

Rotary drilling with Phillips Petroleum Company's tools, operated by the drilling division, was commenced on August 11, 1942, and a 12-in. hole, which was later reamed to 17¼ in. in diameter, was drilled to a total depth of 1940 ft. or 130 ft. into the Permian lime. Then 13⅜-in. O. D. 54.5-lb. J-55 casing was run and cemented with 1600 sacks of regular cement. From this point, an 11-in. hole was drilled to 6901 ft. where a dolomitic formation of a good enough character was encountered for a casing seat, so the hole was reduced to 8¾ in. and drilling continued to 10,008 ft. with the formation penetrated being principally all shales. As no better casing points were encountered, drilling was discontinued and a string of 8⅝-in. O. D. 36-lb. N-80 casing was set at 6901 ft. and cemented with 200 sacks of common Portland cement. This string of 8⅝-in. casing was suspended with a 13⅜ by 8⅝-in., 4000-lb. test hercules type A casinghead.

After setting the 8⅝-in. casing, drilling operations were again resumed and a 7¾-in. hole was drilled from 10,008 ft. to the total depth of 15,279 ft. at which point there existed a total of 8378 ft. of open hole.

A point of interest is the fact that an approximate total of 8000 ft. of shale was penetrated, and had it not been for the well planned and executed mud program that was used on this well, it probably would never have reached anything like the present total depth.

Mostly lime, and a small amount of sandy lime, was encountered for the first 5000 ft. of hole. Shale was not encountered until a depth of over 5000 ft. was reached. Drilling progressed satisfactorily down to 11,457 ft. at which point the first chert was encountered. For the next 7 days, an average of only 3 ft. per day was drilled until the 37-ft. chert section was penetrated. Drilling then progressed normally from 11,494 ft. through mostly shale to 12,829 ft. where chert was again encountered on September 25, 1943. This chert was of an extremely hard nature, approaching the hardness of steel at numerous intervals. Further progress of the well at this time was seriously in doubt for at times (44 times in 125 ft. to be specific) a new bit would fail to make any additional hole whatsoever. During the next 121 days, or until January 24, 1944, only 125 ft. of hole was drilled, or an average of slightly over 1 ft. per day. At only one time during this four-month period did a bit drill more than 2 ft. of hole, and that one time the bit made 3 ft. During this period, 157 round trips were made with the drill pipe and 148 new bits were used. As a matter of interest, this is an average of 1.3 trips per day with the drill pipe and an average of only 10 in. drilled per bit. During this time, 6 wire lines were worn out. Of further interest is the fact that it cost approximately $150,000.00 to drill the chert section, or nearly $1,200.00 per ft.

After the extremely hard chert sec-

(Continued on Page 62)

*Presented before American Petroleum Institute Southwestern District Division of Production, Houston, Texas, June 14, 1944.

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(Continued from Page 59)
tion had been drilled, the well was carried on to the total depth without any further significant difficulty. However, at the 13,029-ft. level operations were shut down while larger rotary equipment was installed. The hole was finally bottomed at 15,279 ft. on April 12, 1944; 21½ months after the surface-hole was spudded. The Ellenberger lime had been topped at 15,075 ft., so consequently 204 ft. of this formation was drilled. A Totco recording instrument was run periodically throughout the drilling of the well and at no time was the hole more than 1¾ deg. from vertical.

After reaching total depth, a Schlumberger electric log of the hole was made and a maximum bottom hole temperature of 238°F. was recorded.

Inasmuch as the depth now was equal to the minimum yield point of the 3½-in. grade D drill pipe, and as our objective had been reached, a decision to run 5½-in. casing was made. The casing string was designed so that we were able to obtain from various stocks on hand all the pipe needed except the 5½-in. 23-lb. Acme and 8-round thread. Fortunately, the Pittsburgh Steel Mills had enough billets on hand to make the required amount of this weight and grade of casing so the order was placed with them, and by May 8, 1944, all casing had been received and was on the racks at the well. Nineteen days time had elapsed from completing the Schlumberger survey until we started laying down drill pipe. During this waiting period, circulation was maintained and a round trip with the drill pipe was made every 36 to 48 hr.

The 5½-in. casing string, consisting of 557 joints, was started in the hole at 1:00 p.m., on May 10, 1944, and 18½ hr. later was landed on bottom. The following is a detailed tabulation of the casing string as it was run, reading from the bottom of the string to the top:

Section and grade	Wt. per ft., lb.	Type of joint	Section		*S.F. in tension	S.F. in collapse
			Set depth, ft.	Length, ft.		
No. 1 N-80	23	8 Rd. LT&C	15,279	2362	HI	1.24
No. 2 N-80	20	8 Rd. LT&C	12,917	2837	3.43	1.25
No. 3 N-80	17	8 Rd. LT&C	10,080	4293	1.74	1.25
No. 4 N-80	20	8 Rd. LT&C	5,787	1762	1.74	HI
No. 5 N-80	23	ACME	4,025	4025	1.50	HI

*Safety factors calculated on A.P.I. minimum values and 9.6-lb. salt water.

The shoe joint was equipped with a Baker up-whirler type guide shoe and two Baker float collars were used; one placed on the upper end of the shoe joint; the other on the upper end of the second joint run. This placed the upper float collar 49 ft. above the shoe.

During the running and cementing of the casing, two drilling crews and a casing crew were on the job. Also on the job, to prevent any unnecessary delays from breakdowns, were specialists and service men from the Wilson Manufacturing Company, Baker Oil Tool Company, Cummins Diesel Engine Service Company, Shaffer Tool Works, Halliburton Oil Well Cementing Company, Trinity Portland Cement Company, Cameron Iron Works, and a welder and truck driver with a truck equipped with winch and shear poles.

After the casing was landed on bottom, circulation was restored at 800 lb. per sq. in. and maintained for 2½ hr. before cementing. As a matter of comparison, it is interesting to point out that circulation pump pressure with the 3½-in. drill pipe in the hole had been 1250 lb. per sq. in. When filling the pipe with mud, while running the casing, care was taken at all times to prevent loading the pipe to in excess of 280,000 lb., which allowed sufficient safety factor in tension. After the pipe had been landed on bottom, it was then filled with mud with care being taken to slack off tension whenever the weight indicator passed the 280,000-lb. mark. Total dead weight of the casing string with letting in joint was 312,414 lb.

The cementing procedure was then begun with 1000 sacks of Trinity Inferno slow-setting cement being used. Three Halliburton cement trucks were used to mix and pump the cement. Tests of the weight of the cement slurry were taken continually at each truck throughout the cementing operation in order to maintain the weight of the slurry at 16 lb. per gal.; this is equivalent to 40 per cent water by weight per sack of cement. Mixing of the cement required 28 min. for the entire 1000 sacks. An especially constructed Halliburton head was used, which held two Halliburton 2-cup rubber plugs. Two plugs were used as a safety factor to prevent any possible bypassing of the cement due to the anticipated high pressure to be encountered. Pumping of the cement plugs down the pipe to displace the cement was begun within 2 min. after the last of the cement was mixed and placed in the casing.

The time elapsed for pumping the cement down to the shoe was 41 min. with a pump pressure of 300 lb. per sq. in. This pressure gradually increased until the cement was equalized at which point the pump pressure was 1100 lb. per sq. in. after a total elapsed pumping time of 53 min. Pressure then continued to increase until just before bumping the plugs on the top float collar, and it reached a maximum of 1800 lb. per sq. in. The pressure was then run up to 2500 lb. per sq. in. and held at that point to determine definitely that the plugs were landed on the top of the upper float collar. A total time of 69 min. elapsed from the time the cement plugs were started down the casing until the cement was displaced and the plugs landed on the upper float collar. This made the total cementing operation, from the time the first sack of cement was mixed until the operation was completed, a period of 97 min. The pressure on the casing was then bled off to a level of 1000 lb. per sq. in. and maintained at that point until the cement was set. This was done to prevent excessive pressure building up in the casing due to the high temperature. A total of 280,000 lb. was maintained on the weight indicator throughout the cementing operation.

Forty-six hours after the cementing operation was completed, a temperature survey was run, recording the height of the cement behind the 5½-in. casing at 10,670 ft. or 4609 ft. above the shoe. On the basis of this figure, 140 per cent of the theoretical amount of cement needed to fill this amount of annular space was used. One of the principal reasons for using as much as 1000 sacks of cement was to seal off a high pressure zone in the hole, which was encountered at approximately 11,500 ft. This objective was accomplished, as indicated by the temperature survey.

After allowing the cement to set for 4 days, 4 ft. of tension, or 86,000 lb., which was 31 per cent of the weight on the indicator, was slacked off and the casing permanently suspended in the casinghead. Since the minimum joint strength of the 5½-in. O.D. 23-lb. N-80 Acme thread casing is 470,000 lb., an approximate safety factor of 2.2 was maintained. This is calculated on the basis of the actual weight of the casing above the cement column, which amounted to 212,593 lb.

Geology

Price No. 1 was located on a structure by geophysics and core drilling by members of the Phillips' Land and Geologic Department. Surface beds are limestones of Comanchean age. The Permian dolomite was encountered at a depth of 1810 ft. The extremely hard cherty zone, from 12,829 ft. to 12,954 ft., that was nearly impossible to drill is probably of Devonian age. Top of the Simpson was encountered at 13,100 ft., and top of the Ordovician Ellenberger Dolomite was reached at 15,075 ft.; 204 ft. of this Dolomite was penetrated to a total depth of 15,279 ft.

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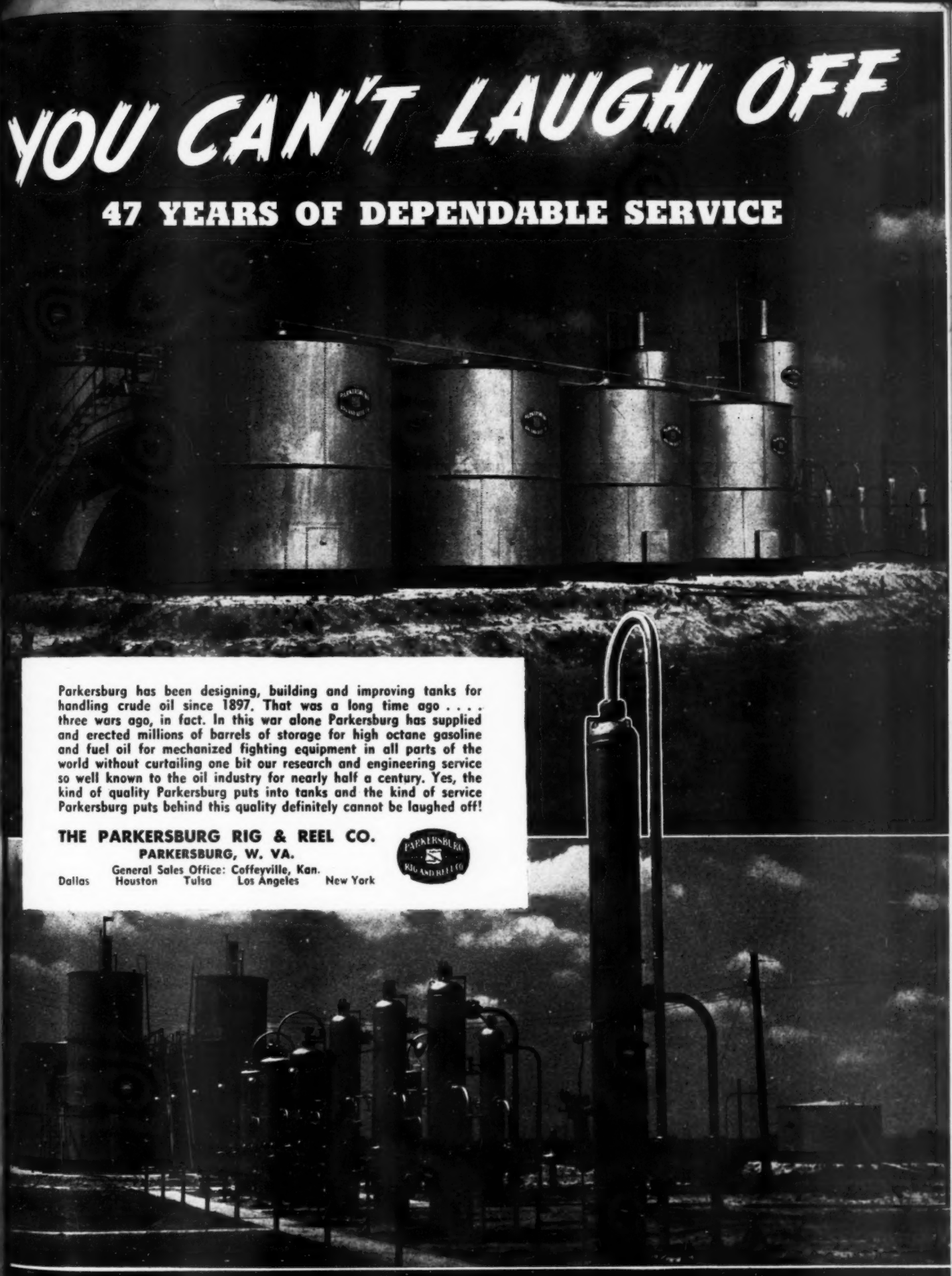

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Reed rock bits of the hard formation type were used throughout the rotary drilling operations. A total of 477 bits were used in drilling from 520 ft. to 15,279 ft. for an average of 30.9 ft. drilled per bit. Total money expended for bits approximated $50,000, or about $3.30 per ft. of hole drilled. As a matter of interest, it might be pointed out that at a depth of 12,857 ft. in the hard chert, 4 new bits were run without making any perceivable hole. Finally, with the fifth new bit in operation and after 3 days of drilling and pulling and running drill pipe, a slim 1-ft. of hole was accomplished.

Wire Lines

Seventeen 6 by 9, 1⅛-in. plow steel Union wire ropes, 2000 ft. in length, were used throughout the rotary drilling. Six of these lines were worn out in the extremely hard 125-ft. chert section from 12,829 ft. to 12,954 ft. The total cost of the wire lines, purchased at $1,250 each, amounted to $21,250.

Equipment

A 136-ft. 400-ton capacity Lee C. Moore derrick with a 30-ft. base and an 8-ft. 500-ton substructure was used throughout the drilling operations. The initial rotary equipment of major importance included:

One Wilson "Atlas Streamlined" drawworks, rated to a depth of 10,000 ft. with 3½-in. drill pipe, but used to a depth of 13,029 ft., was equipped with a 36-in. Parkersburg Hydromatic brake.

Two V-12 350-hp. Le Roi gas engines, operated on butane.

One 7¾-in. by 16-in. Gardner-Denver slush pump, rated 250 b.hp. at 900 lb.; powered by drawworks engines.

One 7¼-in. by 14-in. Oil Well slush pump, rated at 200 b.hp. at 635 lb.; powered by auxiliary V-12 350-hp. Le Roi gas engine, operated on butane.

One 5-sheave 150-ton Emsco series N.B. 36 crown block.

One 4-sheave 120-ton Emsco series N.B. 36 traveling block.

One Emsco type J.C.S. 20¼-in. rotary table.

One National D.F. 150-ton swivel.

One Byron Jackson 150-ton hook.

One 13⅜-in. Cameron, type S.D.A. blowout preventor.

One 13⅜-in. Shaffer, type 34, cellar control gate.

At 13,029 ft. operations were shut down and heavier and stronger rotary equipment was installed, as listed below, which completed the well to its total depth.

One Wilson Titan drawworks, rated to a depth of 15,000 ft. with 3½-in. drill pipe and equipped with a 4-in. Parkersburg Hydromatic brake.

Three LI-600 Cummins diesel engines rated at 225 hp.

One 8-in. by 20-in. F.X.L. Gardner-Denver slush pump, rated at 425 b.hp. and 350 gal. per min. at 1390-lb. pressure; compounded with the 3 engines on the drawworks.

One 7¾-in. by 16-in. F.X.Q. Gardner-Denver slush pump, powered by an auxiliary LI-600, 250-hp., Cummins diesel engine.

One Emsco, type J.C.S. 20½-in. rotary table.

One National D.F. 150-ton swivel.

One Regan, type 4B 76-in. 300-ton 5-sheave traveling block.

One Regan, type EB 6-sheave 360-ton crown block.

One 200-ton Byron Jackson hook.

One set B.J. weldless 3-in. by 108-in. 150-ton elevator links; B.J. type "G" 150-ton elevators.

One 9⅝-in. Shaffer double cellar control gate.

One 9⅝-in. type 34 Shaffer cellar control gate.

Casing tools, running the 5½-in. casing string, consisted of the following:

One B.J. 13⅜-in. 300-ton side door slip casing elevator, equipped with 5½-in. slips.

One B.J. 13⅜-in. 300-ton casing spider, equipped with slips for 5½-in. casing.

Eight complete sets of Standco brake linings at $203 per set were used. Total cost was $1,624.

Approximately $29,592 was spent for butane fuel and $3,822 for diesel fuel for an approximate total fuel cost of $33,414.

Rotary drilling was begun at 520 ft. with 5-9/16-in. O.D. 22.2-lb. I.U. grade "D" drill pipe, which was used to a depth of 4953 ft. From that point to 6901 ft. 4½-in. O.D. 16.6 lb. I.U. grade "D" drill pipe was used, and from 6901 ft. to the total depth 3½-in. O.D. 13.3-lb. I.F.E.U. grade "D" drill pipe was used. The total dead weight of the 3½-in. drilling string when the well was drilling at its total depth of 15,279 ft. was calculated to be 221,316 lb. The calculated weight, considering the buoyancy of the 12½-lb. mud was 180,739 lb. As the minimum yield point of the 3½-in. drill pipe was 199,160 lb., it can be seen that a safety factor of 1.1 existed.

The tension on the top joint, of course, is slightly increased when the pipe is being pulled from the hole. This increase is influenced by the viscosity of the fluid and the speed with which the pipe is removed from the hole. Due to the low speed at which the pipe was removed from the bottom, this factor can be considered as negligible. Should the drill pipe have become stuck, the amount that could have safely been pulled without passing the minimum yield point of the pipe was 18,421 lb., which is about 4 points on a Martin Decker weight indicator with ten 1⅛-in. lines strung in the derrick.

As a point of interest, it might be mentioned that the 3½-in. drill pipe in tension measured 15,279 ft., while the measurement without tension totaled 15,269 ft., or an elongation of 10 ft. I believe the theoretical elongation is calculated to be 10.6 ft.

Drilling Mud

From 520 ft., where rotary drilling was started, to 1940 ft., where 13⅜-in. casing was run, 9.2-lb. to 9.8-lb. mud with a viscosity of 32 seconds was used. From 1940 ft. to 5494 ft. the average mud weight was 9.6 lb. with a viscosity of from 32 to 34.

At about 5200 ft. shale beds had been encountered and by the time 5494 ft. had been reached, it was necessary to treat the mud with chemicals, raise the weight to 10.1 lb. per gal., and increase the viscosity to 46. Water loss was held at 18 cc. or less with filter cake of 5/32 in. This quality of mud was maintained to the depth of 10,008 ft. The 8⅝-in. casing was then set at 6901 ft., and drilling continued from 10,008 ft. to approximately 11,500 ft., with 10.2-lb. per gal. mud, which had a viscosity of 40.

At approximately 11,500 ft. a high pressure zone was encountered. Mud weight was immediately increased to 11.4 lb. per gal.; viscosity was 48 and water loss was reduced to 12 cc. From here on the mud weight was gradually increased until at 13,495 ft. the weight was 12.5 lb. per gal., viscosity at 60, and water loss was 8 cc. with a filter cake of 2/32 in. Mud of these characteristics was maintained to the total depth of 15,279 ft. The pH value of the drilling mud was maintained at approximately 8.3 and very few adjustments were necessary to keep it at that point.

The importance of control of water loss is emphasized by the fact that the open shale section from 6901 ft. to 12,829 ft. (top of the chert) was open from September 2, 1943 to April 12, 1944. The open shale section gave no trouble while the water loss was 9 cc. or less, but when the water loss was allowed to increase to as much as 16 cc., considerable sloughing of the shale occurred.

The following table shows cost of mud used:

Total mud cost (not including drayage)	$25,302.15
Total mud cost (including drayage)	31,492.15
Mud cost per ft. of hole drilled (less drayage) . .	1.71
Mud cost per ft. of hole drilled (with drayage) .	2.13

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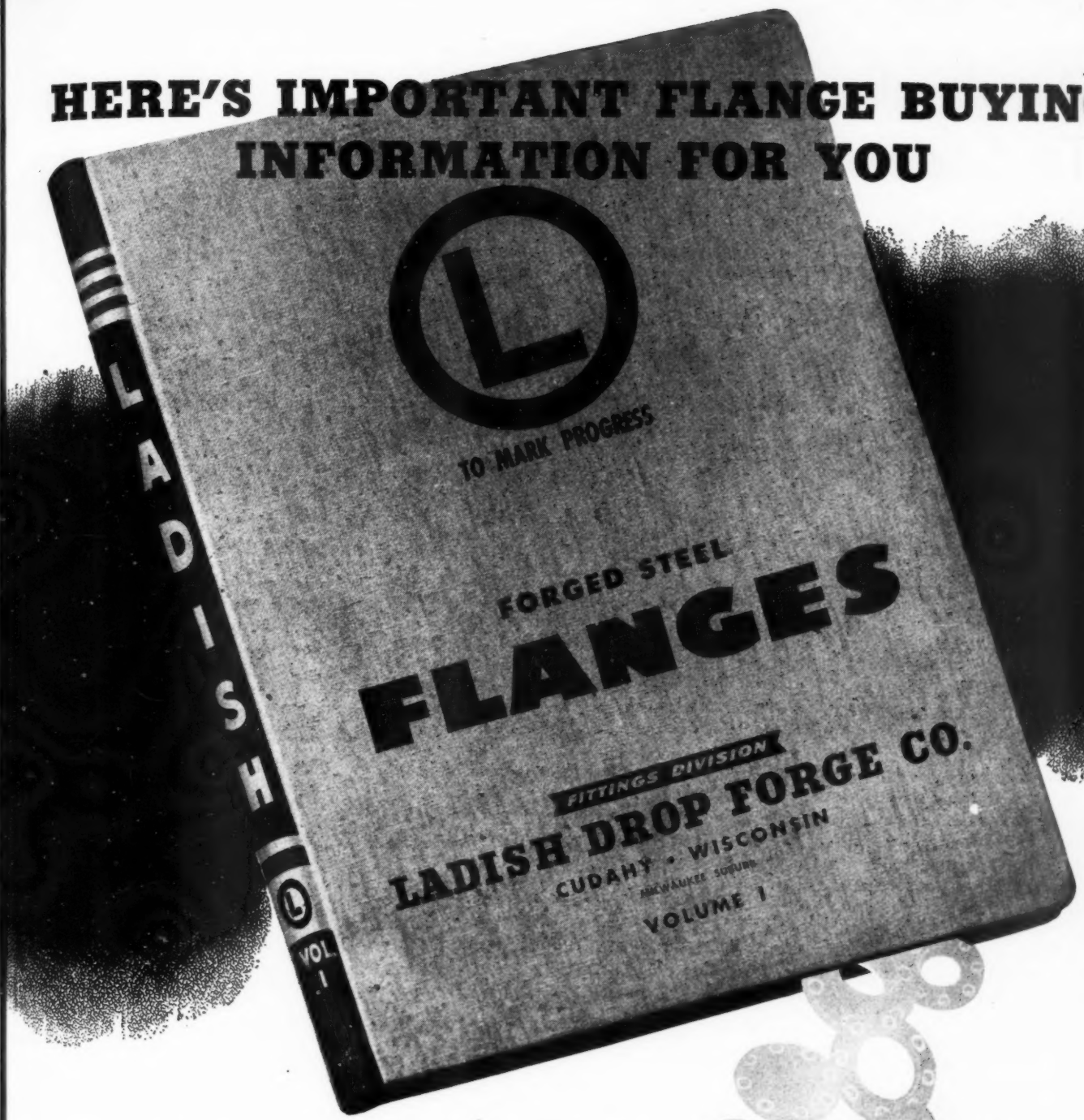

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Application of Radioactivity Logging To Special Drilling Problems

☆ Scope of utility greatly widened since its introduction into the oil industry

PETROLEUM ENGINEER Exclusive Feature

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

As is the case with many technical services and equipment employed in the drilling, production, and maintenance of oil wells, the scope of radioactivity logging has been widened greatly since its introduction into the oil industry a very few years ago. Originally developed to locate cased-off production by providing a log of formations behind one or more strings of pipe, the radioactivity log is now extensively employed not only for that purpose but also to clarify other subsurface records, check depths and thicknesses, furnish data for correlation, and to supply formational data for various down-hole operations.[1] Many special, and sometimes rather unusual, jobs are also being done with the radioactivity log and a discussion of such jobs may indicate the application of radioactivity to similar and other particular conditions.

The gamma-ray curve, which records the measurement of gamma rays originating in the formation and passing through casing and cement, when present, was first used alone to procure formational data in cased or open hole. Later the neutron curve, measuring the effect of bombardment on the formations by a strong source of neutrons, was introduced. This neutron curve is used widely as a companion curve to the gamma-ray curve and will frequently locate strata in which irregularities in radioactivity make the gamma-ray curve inadequate when used alone.

An example of the combined use of the gamma-ray and neutron curves for a specific purpose is in defining porous zones in areas such as West Texas where there is consolidated sedimentation. By using the two curves both the type and physical character of the formation are disclosed. Where limestone formations are present the neutron curve is run in conjunction with the gamma ray to indicate definitely the porous strata containing fluid. Hard dense formations such as anhydrites, impervious limestones, and the like are indicated by high intensity readings of the neutron curve whereas the porous formations are shown by low or moderate intensity. The gamma-ray curve differentiates between the porous formations indicated by the neutron log and the shales.

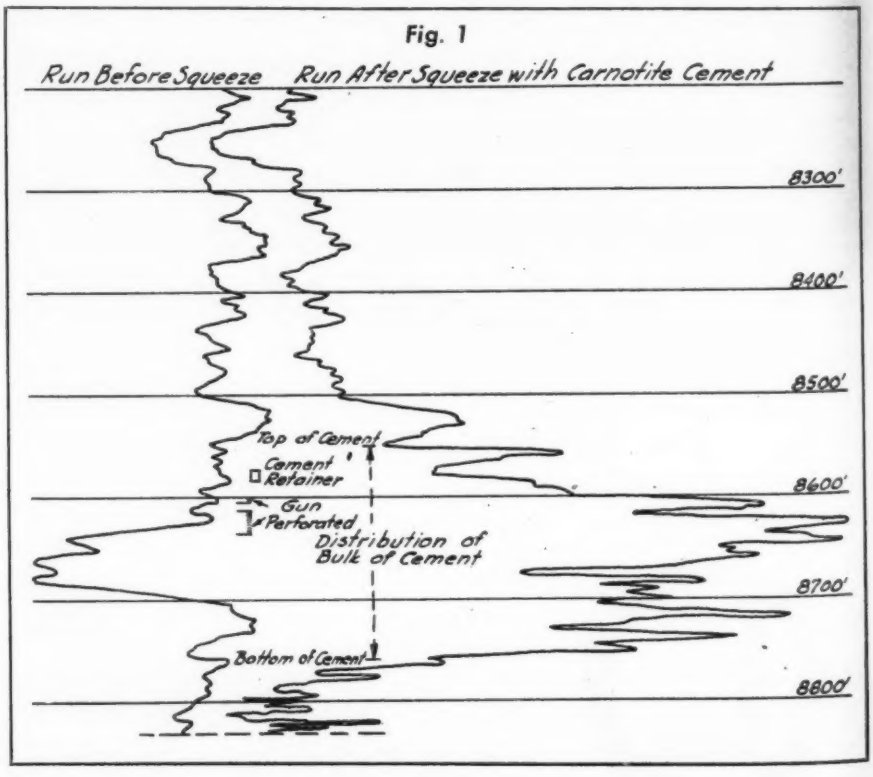
When wells are drilled with muds continuously contaminated by salt beds or excessive flows of salt water a radioactivity survey provides a log that is unaffected by well fluid conditions. Under these conditions the gamma-ray curve is used for lithology and the neutron curve for porosity and density.

One unusual application of radioactivity logging is for locating permeable zones with the aid of radioactive material placed in the drilling fluid. A gamma-ray curve is first run and then a radioactive material is thoroughly mixed with the drilling mud and forced into the formation under pressure. The gamma-ray log is then run again at the same sensitivity as that used with the first run and by a comparison of the two curves the permeable strata are identified.

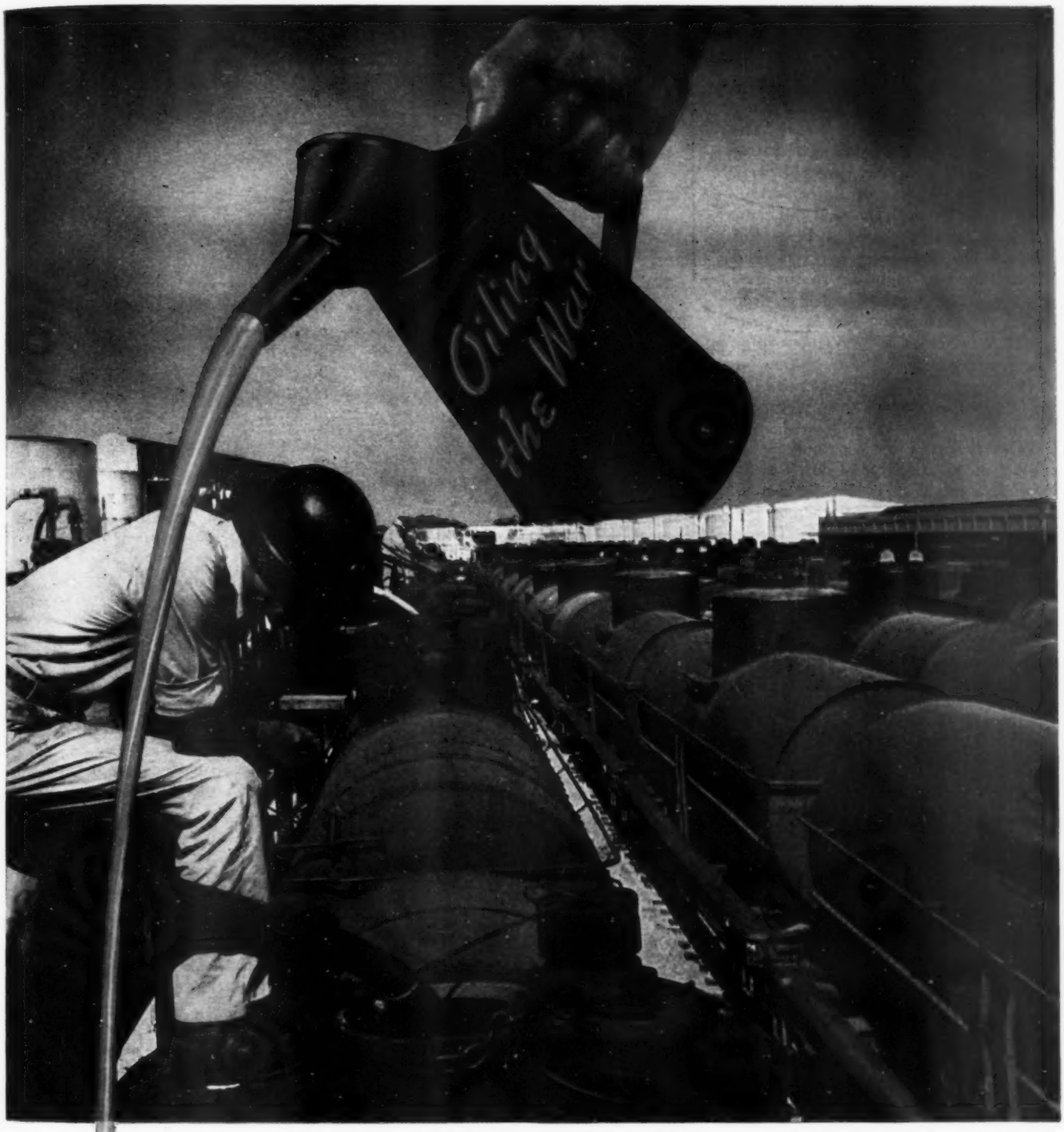
Locating Water Entry

It is sometime difficult to locate the point of entry of a heavy flow of salt water encountered during drilling. While drilling a well in Kansas it was observed that the mud became somewhat frothy and that it thinned considerably after reaching a depth of approximately 2000 ft. Drilling was continued, however, until, upon reaching 3000 ft., circulation was lost. While regaining circulation, salt water came into the hole but the amount was not sufficient to indicate an artesian flow. Circulation was regained by pumping mud and drilling was resumed. At 3400 ft., however, circulation was lost again and at that depth there developed an

Fig. 1



[1]The construction and operation of radioactivity logging equipment and its more general application to oil field use have been discussed in the following articles published in *The Petroleum Engineer*:
"Locating Cased-Off Productive Zones," by Wallace A. Sawdon, May, 1942.
"Radioactivity and Geochemical Well Logging," by Lester C. Uren, January, 1943.
"Locating Cased-Off Production by Radioactivity Logging," by Wallace A. Sawdon, May, 1943.
"Gamma Ray Logging in East Texas," by John L. P. Campbell, January, 1944.



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artesian flow that could not be overcome by any means.

It was decided to make a gamma-ray survey and the instrument was run into the hole as far as it would go. It hung up at a short distance below the point where the heavy flow of water was thought to be entering the well. The line was slacked until the instrument settled through the mud and came to rest on what appeared to be a solid bridge. The gamma-ray log was then taken from that point up to the shoe of the surface casing, which had been landed at a little above 900 ft. A neutron instrument was then run to provide a neutron curve for the same interval as logged with the gamma ray and from this curve several possible porous formations were indicated.

After studying the logs and determining the strata from which the artesian flow might be coming, a cement plug was placed at approximately 100 ft. below the possible water-producing zone indicated by the logs. After this cement had set, another 500 sacks of cement were pumped into the hole to bring the plug almost up to the shoe of the surface pipe. The hole was then redrilled through the cement plug and washed to its original bottom. The artesian flow had been shut off and drilling was resumed.

Use With Carnotite Cement

A special application of radioactivity logging that is now being employed to some extent in the Gulf Coast is the location of cement used in squeeze jobs by means of carnotite mixed with the slurry. Carnotite is a radioactive material and by its presence in the cement the gamma-ray instrument can locate the interval through which the cement extends behind the pipe and the variations of accumulation of cement throughout the limits of the cement.

A gamma-ray log is first run to indicate the formations and to provide a reference for comparison with a later log. The well is then squeezed with cement to which has been added carnotite in a proportion of approximately one pound of carnotite to each sack of cement. A second gamma-ray log of the same intensity as the previous one is taken and by comparison of the two logs the location of the carnotite cement is determined. As shown by Fig. 1 the cement containing carnotite is indicated by the extremely high intensity values on the second curve, in marked disagreement to the first log.

This actual location of the cement behind pipe is particularly useful in areas where trouble is encountered in obtaining successful squeeze jobs. In widely separate productive zones it shows the extent of vertical distribution of the cement and in multiple zones it indicates whether the squeeze covers the formations to be tested or has collected in pockets or cavities. Mass distribution of cement is not always uniform as has been proved by caliper logs, which show considerable irregularity in the diameter of hole. Washed-out sections will accumulate mass and their increased anomalies appearing on the survey indicate the mass and vertical distribution. When the top of the cement is reached (surveying upward) there is a noticeable shift to the left on the curve, which then has for the remainder of the hole a comparable similarity to an electric log of the well or to previously run radioactivity log.

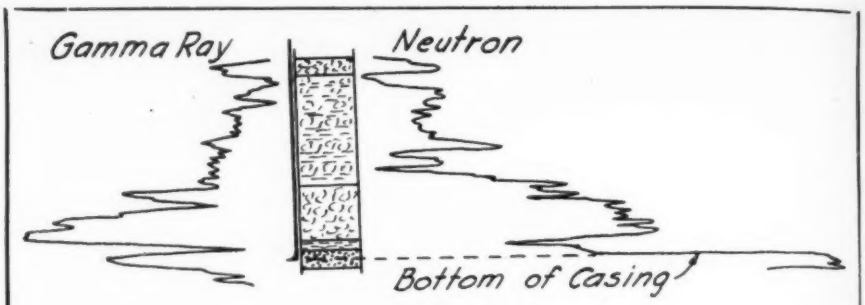

Fig. 2

The curves in Fig. 1 are of a well in Texas in which casing had been cemented and gun perforated at the two places indicated, the perforated zones having been tested with a tool set between these points. The test made it questionable whether the cement was at or near the zones. The curve to the left is the first run made with the gamma ray to record the formations and provide reference.

A cement retainer was set above the perforations at 8580 ft. and the hole squeezed with carnotite cement. The mixture consisted of 100 sacks of cement and 87.5 lb. of carnotite. This was preceded by 6.5 bbl. of water and 75 sacks of the carnotite cement were put behind the casing with a maximum pressure of 5100 lb. per sq. in.

After the cement had set and the hole had been cleaned out, a second log was taken and gave the curve shown on the right in Fig. 1. The top of the cement is here picked up at 8550 ft. and the bottom at 8760 ft., as indicated by the major kicks on the second curve. Some cement is below the indicated bottom but this cement probably consisted of settlings in the pipe or an unconsolidated sheath caused by slight channeling. The bottom indicated is the lowest point of the bulk of the cement.

It is interesting to note that the cement traveled approximately 50 ft. upward from the highest perforation and a little more than 120 ft. downward from the lowest. The greatest mass of cement lay opposite the perforations. It appears that there was no consistent massing opposite the shales due to washing as has frequently been discovered in different areas; but because no caliper log had been made of this hole, no confirmation of this is available.

Other Applications

In passing from a string of casing while running a neutron log, a definite shift occurs on the curve. This is true whether the casing is an inner, intermediate, or an outer string and thus provides a means of locating the shoes of one or more strings of pipe when records are not reliable. In one recent case, it was desired to locate the bottom of each of five strings with which the well was cased, so a neutron log was run to furnish this information.

The gamma-ray log is not greatly affected by the presence of casing so the combination of the neutron and gamma-ray curves is frequently used in recompletions by using the gamma ray to locate the top of the sand and the neutron to locate the shoe of the casing. In many cases the top portion of the oil sand is sealed off by the oil string.

An example of this is illustrated by Fig. 2, which gives curves of a well in the East Texas field. The two logs were run and the bottom of the casing, as shown by sharp break in the neutron curve, was found to be 5 ft. in the sand. In this field the pipe is sometimes set in or through productive zones and surveys are run to determine sections of sand sealed off behind casing or liner.

There are, of course, various other special problems that can be met through the aid of information supplied by radioactivity logging. In the case of blowout, or threatened blowout, where casing has to be run before an electrical log is taken, the formational data can be procured under safe conditions because the radioactivity log can be obtained through casing and cement. In addition to its more widely known use in locating cased-off production and checking subsurface records, there are many unusual conditions encountered in repair and work-over jobs that can be handled more effectively when operations are based on information provided by radioactivity logging.

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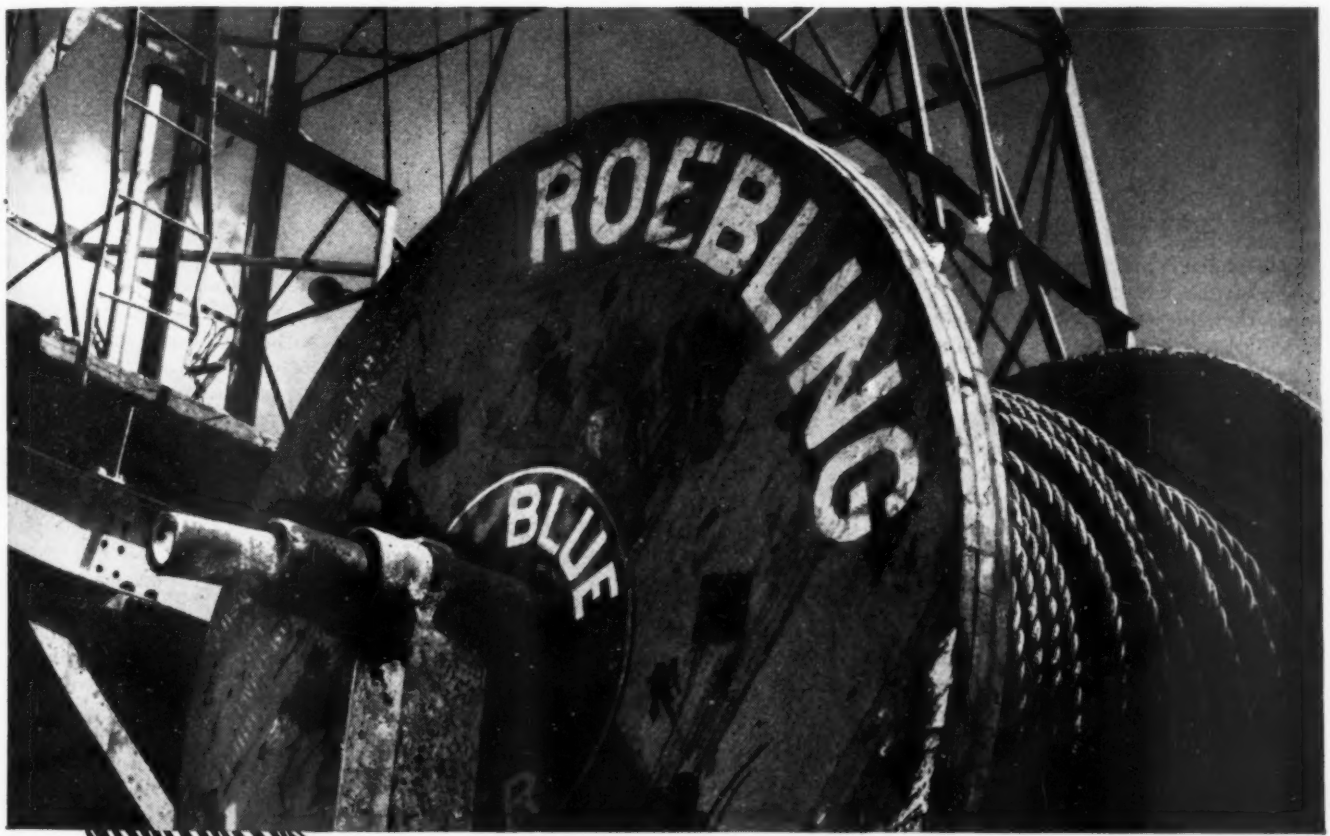

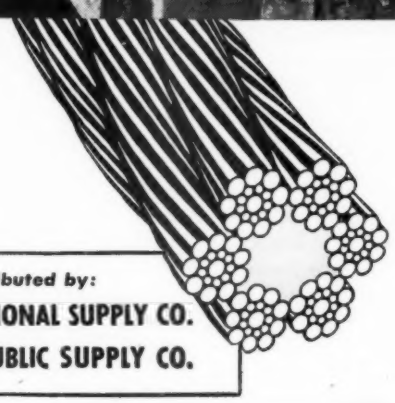

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Chemicals From Natural Gas And Natural Gasoline

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☆ Hydrocarbons contained in these products offer wide field for manufacture of industrial chemicals

by John H. Kunkel
Refinery Editor

IN the days of the alchemist the constant search was for a way to turn base metals into gold. This was thought to be the ultimate of all accomplishments. Perhaps one day base metals will be turned into gold because chemistry has wrought so many wonders that even the most skeptical mind is now puzzled over the question, "Where will it all stop?" Less than 15 years ago it was taught that certain elementary substances found in natural gas and other petroleum fractions were chemically inert and of limited commercial importance other than to contribute properties to gaseous fuel. Today it is increasingly evident that these simple hydrocarbons represent chemical stepping stones that offer a pathway to the synthesis of a host of chemicals of industrial importance. The preparation of isooctane, neohexane, synthetic isobutane and butadiene for synthetic rubber are all rightly part of the pattern of synthetic substances that arise from natural gas hydrocarbons and their first cousins, the gaseous olefins.

Natural gas and refinery gas related. In 1944 it is more difficult to consider the manufacture of chemicals from natural gas hydrocarbons than it was in 1934 because of the tremendous strides made in refining technology during the past decade. The division between what natural gas and gasoline fractions mean to chemical synthesis as compared to what the cracked gases in a refinery bear to the same end is no longer clearly marked. In order to picture specifically the value of the natural gas fractions, a comparative basis must first be established that includes the refinery gas fractions as well.

For years it has been almost traditional to think of natural gas hydrocarbons as substances found only in a natural gasoline plant. Now it is evident that all the substances present in natural gas, with the exception of helium, can be found in refinery gases. The major difference lies chiefly in the fact that the process for natural gasoline recovery offers a means of selectively concentrating large amounts of the desirable paraffinic hydrocarbons without the introduction of certain complexities in recovery and fractionation that the refiner has to meet because of the presence of other gaseous compounds.

The natural gasoline manufacturer recovers his fractions from the natural gas as it is produced from the well. The refiner recovers, in part, some of the natural gas and gasoline fractions that remain dissolved in the crude oil delivered to the refinery. But the refiner also brings into existence additional quantities of these same fractions through the breaking down of heavier petroleum compounds by cracking.

Nature of "wet" natural gas. A wet natural gas that contains recoverable natural gasoline fractions may be taken as composed of: Methane, ethane, propane, isobutane, butane, isopentane, pentane, hexanes, and heptanes. The hexanes and heptanes will be excluded from consideration in relation to the synthesis of chemicals.

Natural gasoline composition. After the wet natural gas has been treated in a gasoline plant, the natural gasoline product may be taken to consist of: Isobutane, butane, isopentane, pentane, hexanes, and heptanes.

"Dry" natural gas chiefly methane. The residue or "dry" gas that leaves the absorbers after the gasoline fractions have been washed out by the absorption oil may be thought of as composed of: Methane (predominantly), ethane (variable amounts), propane (small amounts), together with small amounts of heavier fractions.

Liquefied petroleum gases. If liquefied petroleum gas products are recovered these may be taken to consist of: Propane, isobutane, and butane in various combinations to meet selected specifications or in pure or near-pure individual compounds. Table 1 illustrates the distribution of natural gas hydrocarbons in a typical gasoline plant. Different plants will of course differ in the distribution of the fractions as well as in the composition of the resultant products.

Natural gas and certain refinery hydrocarbons differ. The natural gas and gasoline hydrocarbons are made up of particles, or atoms, of carbon to which are attached atoms of hydrogen to form various molecular patterns. The number of carbon particles, their arrangement, and the corresponding number of the hydrogen particles determine the nature of the compound. For example, methane consists of one atom of carbon surrounded by four atoms of hydrogen.

Ethane, another natural gas hydrocarbon, consists of two carbon atoms surrounded by six hydrogen atoms. If cracking should cause the ethane to give up two of the hydrogen atoms a new substance, ethylene, would be formed. The ethylene, being devoid of two hydrogen atoms, is spoken of as being "unsaturated." Chemically, this means that ethylene can be caused, under selected conditions, to react with substances other than hydrogen to form new compounds. Chlorine can be substituted for the hydrogen to cause the formation of ethyl chloride, or nitrogen and oxygen substituted to bring about the formation of nitroethane.

And so on with the other natural gas fractions. Propane can be made to lose hydrogen to form propylene; isobutane to form isobutylene, and butane to the butylenes. Table 2 gives some of the physical properties of natural gas and refinery hydrocarbons and reveals the structural difference that occurs as the relationship of the hydrogen atoms varies. Note the column headings titled "structural formula" and observe the difference between ethane and ethylene, and so on.

Synthesis the formation of new compounds. In creating new compounds from natural gas fractions, the hydrocarbons can be thought of as chemical building blocks. By heat, pres-

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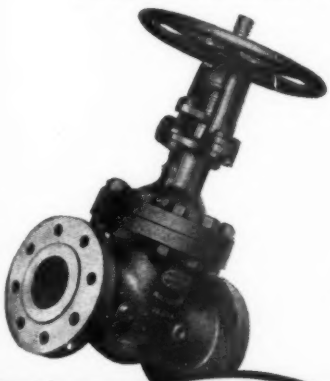

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sure, times, and catalysis they are altered so that they rupture, or "crack," into fragments that possess new properties. Or other substances, such as oxygen, nitrogen, chlorine, etc., are caused to fill the chemical gaps that open as hydrogen atoms are displaced to yield new compounds embodying these added elements.

Tables have been published showing many chemicals that may be formed from simple hydrocarbons such as ethane. However, the natural gas hydrocarbon itself could more properly be thought of as the chemical cornerstone upon which is supported the many chemical changes that make possible the synthesis of compounds far removed from the original step that rendered the basic material chemically reactable.

Ways of synthesizing new compounds. Several basic approaches are possible for synthesizing new chemical compounds from natural gas hydrocarbons. These may be termed conversion by thermal decomposition (cracking), oxidation, halogenation, and nitration.

As mentioned previously, the gas fractions can be broken down by heat into other hydrocarbon forms, some of which are very reactable. After these unsaturated products have come into existence they, in turn, can enter into other reactions. Some of these reactions, known as alkylation, polymerization, isomerization, aromatization, and cyclization, are now of tremendous commercial importance to the war effort and to the future of the refining industry.

Oxygen, air, or nitrogen-containing compounds can be utilized to bring about the oxidation of natural gas fractions into other forms. If combined with selected gas fractions chlorine and bromine result in a chemical reaction spoken of as halogenation. When nitric acid reacts with gas hydrocarbons nitro derivatives are formed. This is known as nitration.

Cracking natural gas fractions. Methane, the simplest of the natural gas hydrocarbons, can be heated-treated to bring about the formation of acetylene. This substance has wide application as a fuel for welding and cutting because of its high carbon content and high calorific value.

Hydrogen gas can also be made through the cracking of methane. The hydrogen then becomes of prime importance in the hydrogenation of other petroleum fractions for the production of aviation gasolines and heat-resisting lubricating oils. Cottonseed oil can also be hydrogenated to yield products such as Crisco. Many other vegetable and fish oils can be treated similarly.

Ethane yields ethylene when cracked. Ethane, if properly cracked, will yield ethylene. The ethylene in turn can be caused to combine with water catalytically to give ethyl alcohol, or synthetic grain spirits. If the synthetic ethyl alcohol is changed by the removal of some of the hydrogen and oxygen, ethyl ether results.

If the ethylene is decomposed further, acetylene will be formed. This latter substance is very active chemically and forms the base for building up such compounds as acetaldehyde. Acetaldehyde can be used as a solvent and in the preparation of certain drugs. It can be used in the preparation of vinyl acetylene, which enters into the manufacture of the synthetic rubber neoprene; in acetone; in acetic acid, and in many other chemicals with valuable solvent properties.

The ethylene derived from the cracking of ethane can, in another direction, form the basis for the building up of such compounds as ethylene chlorohydrin, which can be treated to yield the anti-freeze ethylene glycol. Ethylene can also enter into the manufacture of the synthetic rubber thiokol.

Ethane, the original substance, can be cracked to obtain yields of butadiene, which enters into the manufacture of buna-S and buna-N synthetic rubbers; to obtain benzol, from which can be derived different solvents as well as styrene for synthetic rubber, and toluene and xylene, which have unusual solvent properties, the former being particularly applicable to explosives manufacture.

Propylene from propane. Through selective cracking propane can be caused to yield ethylene, butadiene, benzol, and toluene in the same manner as ethane. In addition the unsaturated hydrocarbon propylene can be formed.

Starting with propylene many different chemicals can be made. Among these are isopropyl alcohol with its solvent properties; propylene chloride, which can be used in the preparation of resins; isopropyl ether, with its exceptionally high anti-knock properties, and many other compounds of commercial value.

Isobutane and butane yield valuable products. Under proper conditions isobutane can be cracked to yield isobutylene. This in turn can become the cornerstone for building up many interesting substances. Chief among these is isooctane.

The isobutylene can now be used to synthesize tertiary butyl alcohol; di, tri, tetra and polyisobutylenes, which enter into the preparation of high octane fuels and additives for lubricants, and methallyl chloride, which is used to build up methyl methacrylate resin, known commercially as Lucite.

When butane is decomposed by thermal cracking, butylene is formed. This substance then becomes the basis for building up such chemicals as secondary butyl alcohol and other solvents, butadiene for synthetic rubber, alkylated polymers for high octane fuels, and sulphur dioxide resins for moulded plastics.

Oxidation of methane yields formaldehyde. The proper addition of oxygen to methane results in the formation of methyl alcohol, or synthetic wood spirits. Methyl alcohol is a good anti-freeze agent and a solvent, and can be used to form lacquer solvents and other refrigerants.

Formaldehyde and formic acid can also be made from methane. Sometimes when a gas oven is first lighted a pungent, acrid odor is often noted, which brings tears to the eyes. This is due to the formation of a small amount of formaldehyde during the initial momentary stage when combustion may be incomplete, the air supplying the oxygen. Formaldehyde is a powerful preservative and disinfectant. When combined with carbolic acid (phenol), it brings about the formation of Bakelite. Formaldehyde also enters into the formation of casein and urea resins. Formic acid is used in electroplating dyeing, and tanning.

Ethane oxidation products. As mentioned previously ethane can be oxidized to yield ethyl alcohol. It can also be converted to supply methane for the formation of formaldehyde and formic acid.

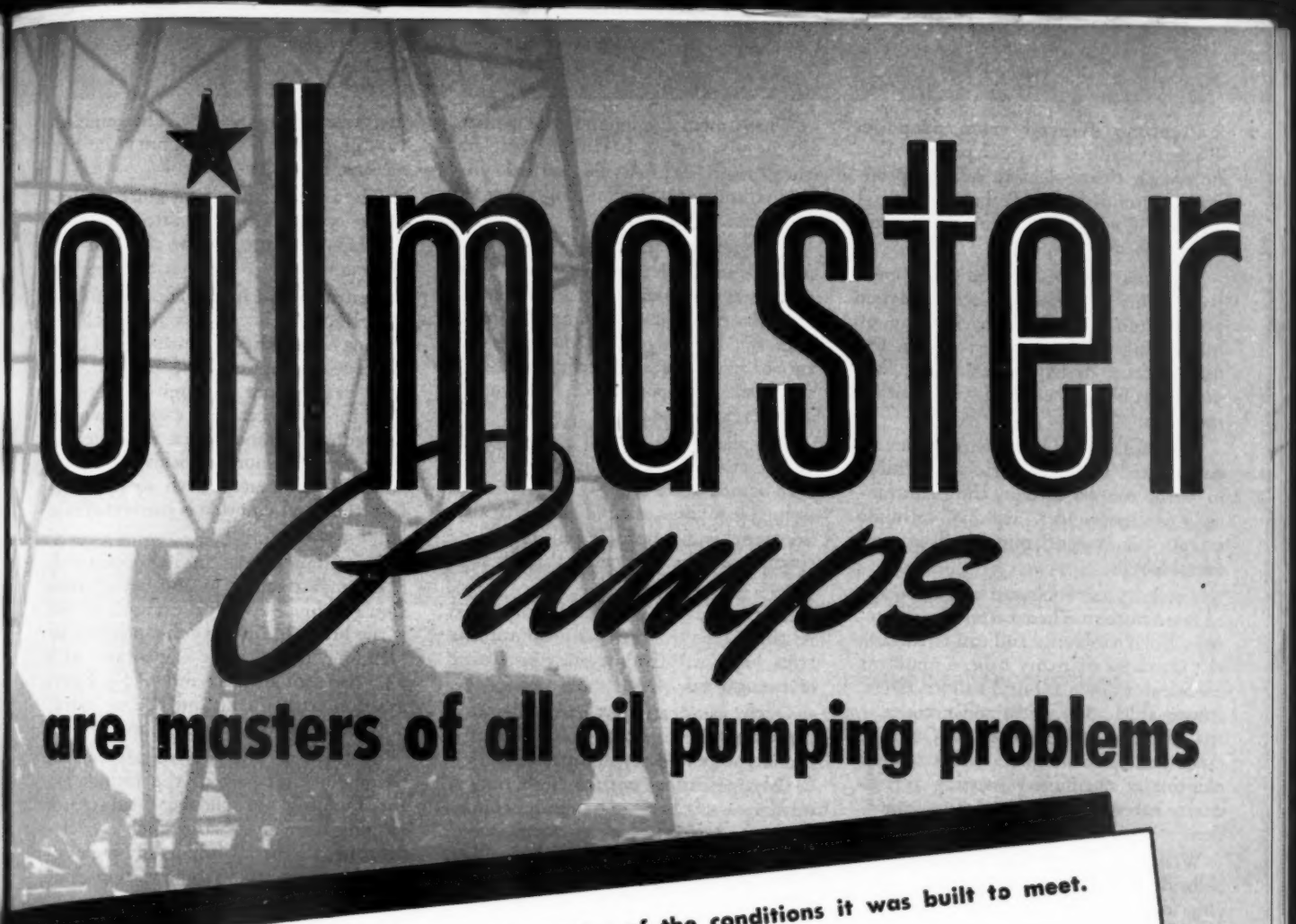
Ethane can also be oxidized to form acetaldehyde, a chemical used in the manufacture of resins and dyestuffs and for the synthesis of n-butyl, hexyl and octyl alcohols.

TABLE I

Characteristic natural gas and gasoline hydrocarbon mixtures

Saturated (paraffin) hydrocarbons

Hydrocarbon	Mixture	Wet gas to absorber	Dry gas from absorber	Raw natural gasoline	Rectifier overhead vapor	Finished natural gasoline product	Liquefied petroleum gas
Methane,	per cent by vol.	71.09	78.43	0.13	7.69	0.00	0.00
Ethane,	per cent by vol.	12.63	13.55	0.45	14.39	0.00	1.40
Propane,	per cent by vol.	9.38	7.87	4.37	77.92	0.09	98.60
Isobutane,	per cent by vol.	1.50	0.04	10.90	0.00	11.66	0.00
Butane,	per cent by vol.	3.26	0.07	22.06	0.00	23.18	0.00
Isopentane,	per cent by vol.	0.71	.....	9.29	0.00	10.52	0.00
Pentane+heavier		1.43	0.04	52.80	0.00	54.55	0.00



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Acetone derived from propane. Propane oxidizes to yield propyl alcohols with their selective solvent properties. One of these alcohols, isopropyl alcohol, is widely substituted for grain alcohol in solvents, etc.

Acetone can be formed from propane. This material has wide solvent powers and is used in the refining of lubricating oils and waxes; and in the manufacture of explosives, resins, lacquers, rubber, celluloid, and other products.

Alcohols from butane. Butane can be oxidized to form acetic acid which, in turn, can be used in the manufacture of insecticides, acetone, cellulose acetate for non-inflammable films, and acetaldehyde.

The butyl alcohols can also be formed from butane. These materials are useful selective solvents and can enter into the synthesis of many other important chemicals known as butyl halides, esters, ethers, aldehydes, acids, and ketones.

Chlorination of methane. Chlorine combined with methane yields methyl chloride, a chemical possessing refrigerant, solvent, and anesthetic properties.

With additional chlorine, methylene chloride chloroform and carbon tetrachloride are made. The first two chemicals find application as anesthetics and solvents. Methylene chloride is also a refrigerant. Carbon tetrachloride is also a good solvent, and can be used in fire extinguishers and as an insecticide.

With bromine, methane forms methyl bromide, which has utility as a fire extinguishing agent and insecticide.

The polychloroethanes. Ethane, when pretreated and chlorinated, can yield ethyl chloride, ethylene chloride, and a complex mixture of polychloroethanes. These substances possess various solvent properties. Some are anesthetics, some refrigerants, and some can be used as flotation agents.

Chloropropanes and butanes. Propane when chlorinated can yield the chloropropanes. One of these compounds is cyclopropane, a valuable anesthetic.

When the butanes are chlorinated, the chlorobutanes are the result. These materials have solvent properties.

Nitration of natural gas hydrocarbons. The nitration of natural gas hydrocarbons results in the formation of chemicals that are steadily increasing in commercial value.

Nitromethane can be made from methane, propane, and butane as base materials. Nitroethane results from the treatment of ethane; the nitropropanes can be derived from propane and isobutane; while the nitrobutanes can be built up from butane and isobutane.

These nitro compounds are utilized in the preparation of rubber accelerators, high explosives, emulsifying agents, solvents, plastics, and for many other uses.

Alkylation, aromatization and other chemical changes. In the past ten years the search for high octane fuels has brought about amazing processes for juggling the chemical structure of natural gas and refinery gases to synthesize compounds of tremendous commercial value.

The alkylation process can bring together ethylene and isobutane to form high octane neohexane. If isobutane and isobutylene are reacted catalytically, isooctane is formed. When propylene reacts with benzol the valuable substance, cumene, results.

Typical of the aromatization process is the catalytic synthesis of toluene from heptane. Heptane is a constituent of natural gas.

Cyclization can convert unsaturated compounds, such as pentene-1, into the cyclic compounds cyclopentane.

Polymerization creates high octane substances by bringing together butylene-1 and isobutylene to form isooctene. The catalytic coupling together of two molecules of isobutylene also results in the formation of isooctene. Upon hydrogenation the isooctene is converted into isooctane. The combination of propylene and isobutylene synthesizes isoheptane.

The isomerization procedure catalytically converts butane into isobutane. Similarly, hexane can be changed into isohexane.

Pentane and isopentane valuable. Amyl acetate, known commercially as banana oil, was first manufactured from pentane during the last World War. This came about through the critical need for amyl acetate in explosives manufacture. Pentane, when subjected to the action of chlorine, yields amyl chloride. When treated with sodium acetate the amyl chloride is converted into amyl acetate.

Isopentane plays an important role in the manufacture of 100-octane aviation gasoline. A typical example of this is the building up of such a product by blending 18 per cent isopentane with 34.5 per cent alkylate and 47.5 per cent aviation base stock, and adding tetraethyl lead to obtain 100 octane.

Thus the natural gas hydrocarbon has become a vital part of the foundation for building up chemical substances ranging from anesthetics, such as cyclopropane, to the all important high octane blending stocks for aviation gasolines.

——— ☆ ☆ ☆ ———

TABLE 2

Physical constants

Natural gas and natural gasoline hydrocarbons				Refinery gas hydrocarbons			
Hydrocarbon & formula	Structural formula	Boiling point	Vapor pressure	Hydrocarbon & formula	Structural formula	Boiling point	Vapor pressure
Methane CH_4		—258.5°F.	Above the critical temperature				
Ethane C_2H_6		—128.2°F.	570 lb. at 70°F. +C.T. at 100°F.	Ethylene C_2H_4		—152.3°F.	Above the critical temperature
Propane C_3H_8		—43.8°F.	125 lb. at 70°F. 189 lb. at 100°F.	Propylene C_3H_6		—53.9°F.	150 lb. at 70°F. 223 lb. at 100°F.
Isobutane C_4H_{10}		+10.0°F.	46 lb. at 70°F. 73.5 lb. at 100°F.	Isobutylene C_4H_8		+20.1°F.	40 lb. at 70°F. 68 lb. at 100°F.
Butane C_4H_{10}		31.1°F.	31 lb. at 70°F. 52 lb. at 100°F.	Butylene-1 C_4H_8		20.3°F.	39 lb. at 70°F. 67 lb. at 100°F.
Isopentane C_5H_{12}		82.3°F.	11.5 lb. at 70°F. 20.3 lb. at 100°F.	Butylene-2 C_4H_8		38.7°F.	29 lb. at 70°F. 50 lb. at 100°F.
Pentane C_5H_{12}		97.0°F.	8.7 lb. at 70°F. 15.5 lb. at 100°F.				

The Refinery of the Future

☆ A survey of possible postwar market demands and processes

PETROLEUM ENGINEER Exclusive Feature

by R. G. Lovell

Development Engineer
Hancock Oil Company of California

PART 1

UNDOUBTEDLY there will be distinct changes in the nature of demands for petroleum products with the removal of the present necessary military control over these demands. The tendency to view the advances in petroleum processing developed during the war period as completely revolutionary and totally outside previous knowledge is not entirely true. Many of the processes that have played a major part in one of the production marvels of history were known to refinery technicians long before vital national necessity transformed them from laboratory novelties into actual production implements.

Because not all readers are petroleum chemists, but are interested in other phases of the industry, it might be well to explain simply something of the nature of the crude material with which the refinery technician works. The hydrocarbon molecule is so small that a million of them could dance on the head of a pin, but despite their size, they can be rearranged into literally millions of combinations, each having different chemical and physical properties. This is largely due to a curious property of the carbon atom of the molecule. The carbon atom is unlike any other in that it can combine with other carbon atoms almost without limit if hydrogen is included in the compound. The chemistry of hydrocarbons is, in fact, so broad and diverse that no one person can possibly be familiar with more than a small part of it. An example of this rearrangement of the carbon and hydrogen atoms in the molecule is found in the fact that, whereas one arrangement produces the principal ingredient in synthetic rubber, which can bounce a little, only a slightly different arrangement produces toluene that, when refined to TNT, can bounce considerably more than a piece of rubber.

Fuel and lubricants for land vehicles have always been and for a long period of time will probably continue to be the refiners chief source of revenue.

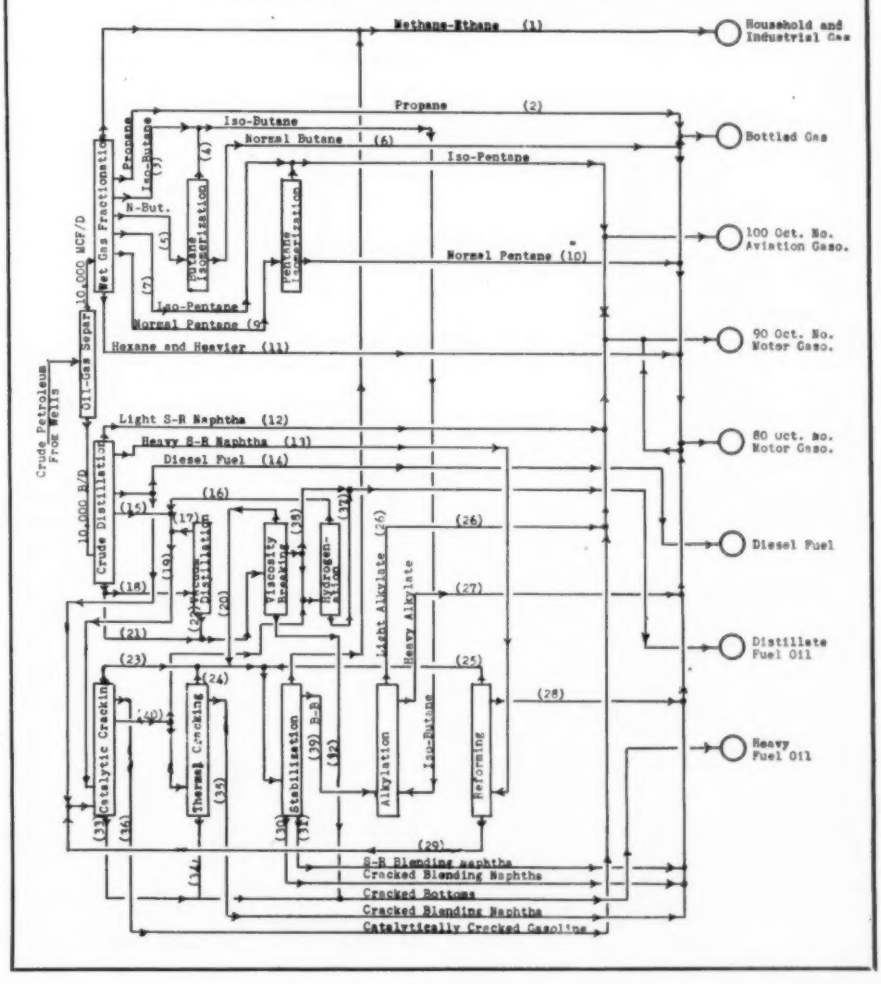
It is obvious that the complete design of perhaps $10,000,000 worth of oil refinery, a composite picture of the refinery of the future (Fig. 1), cannot be shown on paper, nor has any attempt been made to do so. The writer hopes to present additional details in subsequent articles but the objective of the drawing and the accompanying description is to assist the small, independent refiner to foresee the probable nature and scope of his future operations and to calculate them, not from the engineer's heat balance but rather from his own "dollar balance." Liberal quotations from current literature on the subject have been made with the sole purpose of outlining the target with highly colored, but low-score circles, the better to see the bull's eye of profitable operations.

Gasoline Specifications

It is an old story by now of how compression ratios have been stepped up during the last 35 years and each step-up has brought about more power per cubic-inch of piston displacement, but the fact that each advance in compres-

(Continued on Page 80)

Fig. 1. Composite picture of the refinery of the future



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Gas, Butane and Diesel Engines, Generating Sets

(Continued from Page 77)

sion ratio has set up new problems and that each of these problems has been overcome, seems to have been forgotten. The difficulties were surmounted by cooperative work between the automative and petroleum industries, and the prediction that the limit has been reached and that there is not likely to be further progress comes as a distinctly sour note.

Almost from the beginning it was realized that the pressure developed by the combustion of an air-gasoline vapor mixture of combustible proportions was fairly constant at four times the pressure of the mixture before it was ignited. This made an attractive mark for the engine designer to shoot at, but as soon as he began to take advantage of the knowledge, the car buyer began to demand larger, more luxurious and, consequently, heavier cars and he wanted them to go faster. Thus the automobile manufacturer was unable to reduce the size and weight of the engine as he increased the compression ratio.

It was but natural to increase engine speeds as an aid in holding down weight and it was found that by effecting the changes in valve action necessitated by higher engine speeds, an unlooked for thing occurred: The compression pressure before ignition was considerably above the figure represented by compression ratio times atmospheric pressure, which helped materially in increasing power output per cubic inch of displacement. All this was the result of higher velocity of air and air-fuel mixture through the intake manifold and inlet valve ports. This increase in compression pressure over the calculated amount in the average engine is about 40 per cent at 1000 r.p.m.

Rather early in the upward march of compression ratios the knock tendency entered the problem. The automotive engineers, however, were not easily discouraged and refused to accept the judgment of the reactionaries who were even then, as now, declaring that the limit of compression pressures had been reached. The automotive people simply demanded that the oil refiners produce a fuel that would resist the knock tendency. Through improved methods of processing and blending a distinct improvement was made and it was also found that proper use of TEL added still further to the ability of the gaso-

PHYSICAL CONSTANTS USEFUL IN PETROLEUM REFINING

	Name	Synonym	Molecular weight	Boiling points, °F. at 14.7 lb./in.² accepted values	Boiling points, °F. at 100 lb./in.² approx. values	Boiling points, °F. at 500 lb./in.² approx. values	Liquid density: Sp. gr. 60°/60° °F.	Liquid density: Degrees A.P.I.	Liquid density: Lb./gal. at 60°F.	Vapor density, Specific gravity (air = 1.0)	Vapor density, Cu. ft. vapor per gal. liquid at 60°F. and 14.73 lb./in.²	Heat of combustion[5]—gross B.t.u./lb.	Heat of combustion[5]—gross B.t.u./cu. ft.	Octane number motor method	Vapor pressure at 100°F. lb./in.² abs.
Paraffins														**Paraffins**	
1	Methane		16.0	−258	−205	−133	0.247[1]	440[1]	2.10[1]	0.554	49.5[1]	23,880	1,013	>100	—
2	Ethane		30.1	−128	−47	59	0.378[2]	243[2]	3.15[2]	1.049	39.3[2]	22,320	1,792	>100	—
3	Propane		44.1	−44	55	184	0.510[3]	146[2]	4.24[2]	1.562	36.4[2]	21,660	2,590	100	191.0
4	Butane (iso)		58.1	14	122	266	0.567[2]	118[2]	4.72[2]	2.066	29.8[2]	21,260	3,363	99	71.0
5	Butane (N)		58.1	31	144	298	0.582[2]	111.5[2]	4.85[2]	2.066	30.6[2]	21,310	3,370	92	52.0
6	Pentane (neo)	2,2-dimethyl propane	72.1	49	166	—	0.597[2]	105.5[2]	4.97[2]	2.487	26.1[2]	20,970	3,993	83	38.0
7	Pentane (iso)	2-methylbutane	72.1	82	209	—	0.625	94.9	5.20	2.487	27.3	21,025	4,008	89	20.3
8	Pentane (N)		72.1	97	222	—	0.633	92.0	5.27	2.487	27.7	21,090	4,016	61	15.5
9	Hexane (neo)	2,2-dimethylbutane	86.2	122	253	—	0.653	85.2	5.44	2.973	23.9	20,680	4,706	96	9.7
10	Hexane	2,3-dimethylbutane (Di-isopropyl)	86.2	136	268	—	0.666	81.0	5.54	2.973	24.4	20,630	4,700	95	7.1
11	Hexane (iso)	2-methylpentane	86.2	140	274	—	0.658	83.5	5.48	2.973	24.1	20,860	4,748	73	6.1
12	Hexane	3-methylpentane	86.2	146	282	—	0.668	80.3	5.56	2.973	24.4	20,750	4,722	75	5.9
13	Hexane (N)		86.2	156	294	—	0.663	81.9	5.52	2.973	24.3	20,940	4,762	25	5.0
14	Heptane	2,2,3-trimethylbutane	100.2	178	319	—	0.694	72.4	5.78	3.459	21.8	20,620	5,455	>100	3.1
15	Heptane (iso)	2-methylhexane	100.2	194	337	—	0.683	75.7	5.69	3.459	21.5	20,640	5,460	45	2.3
16	Heptane (N)		100.2	209	355	—	0.688	74.2	5.73	3.459	21.6	20,860	5,521	0	1.6
17	Octane (iso)[4]	2,2,4-trimethylpentane	114.2	211	357	—	0.696	71.9	5.79	3.944	19.2	20,540	6,190	100	1.72
18	Octane	2,5-dimethylhexane (Di-isobutyl)	114.2	229	378	—	0.698	71.2	5.81	3.944	19.2	20,540	6,190	55.7	1.1
19	Octane (N)		114.2	258	412	—	0.706	68.9	5.88	3.944	19.5	20,580	6,210	<0	0.6
20	Nonane (N)		128.2	303	467	—	0.722	64.5	6.01	4.428	17.7	20,480	6,950	<0	0.2
21	Decane (N)		142.3	345	514	—	0.734	61.3	6.11	4.915	16.2	20,387	7,670	<0	0.1
Naphthenes														**Naphthenes**	
22	Cyclopropane		42.1	−27	75	209	0.720 at −110°F.		—	1.451	—	21,270	2,365	—	150
23	Cyclobutane		56.1	55	124	330	0.690[2]	73.5[2]	5.75[2]	1.938	38.8[2]	20,390	3,020	—	35
24	Cyclopentane		70.1	121	251	—	0.749	57.4	6.24	2.422	33.7	20,130	3,730	83	9.6
25	Cyclohexane		84.2	177	318	—	0.783	49.2	6.52	2.905	29.4	20,100	4,475	77.2	3.2
Olefins														**Olefins**	
26	Ethylene	Ethene	28.1	−155	−81	18	0.41[1]	214[1]	3.41[1]	0.974	45.6[1]	21,645	1,614	81	—
27	Propylene	Propene	42.1	−54	44	170	0.526[2]	137.5[2]	4.38[2]	1.451	39.4[2]	21,040	2,336	85	221
28	Butylene (iso)	2-methylpropene	56.1	20	130	280	0.606	102.1	5.04	1.936	34.0	20,730	3,068	87	63
29	Butylene (α)	Butene-1	56.1	21	131	281	0.603	103.0	5.02	1.936	33.8	20,840	3,084	80	62
30	Butylene (β)	Butene-2	56.1	34	146	300	0.616	98.3	5.13	2.004	33.4	20,480	3,140	83	51
31	Amylene (N)	Pentene-1	70.1	97	222	—	0.654	84.8	5.45	2.420	29.4	20,710	3,836	92[3]	16
Diolefins														**Diolefins**	
32	Butadiene-1,3		54.1	24	136	286	0.629	93.4	5.24	1.869	36.6	20,250	2,895	—	58
33	Butadiene-1,2		54.1	50	167	—	0.662	82.2	5.51	1.869	39.6	20,310	2,900	—	54
Acetylene														**Acetylene**	
34	Acetylene	Ethyne	26.0	−119	−35	72	0.621 at boiling point			0.911	—	21,500	1,499	80[3]	—
Aromatics														**Aromatics**	
35	Benzene		78.1	176	315	—	0.879	29.4	7.32	2.694	35.5	18,210	3,751	>100	3.4
36	Toluene	Methylbenzene	92.1	231	381	—	0.869	31.3	7.24	3.176	29.8	18,440	4,484	>100	1.0
Miscellaneous solvents														**Miscell. solvents**	
37	Acetone	Propanone	58.1	134	—	—	0.786	48.5	6.54	2.002	42.6	13,600	2,085	—	—
38	Methyl-ethyl Ketone	Butanone	72.1	175	—	—	0.809	43.4	6.74	2.485	35.4	14,500	2,760	—	—
39	Methyl alcohol	Methanol	32.0	148	—	—	0.796	46.3	6.63	1.105	78.4	10,260	868	—	—
40	Ethyl alcohol	Ethanol	46.1	173	—	—	0.794	46.7	6.61	1.591	54.3	13,160	1,600	—	—
41	Furfural		96.1	323	—	—	1.164	−10.0	9.70	3.320	38.2	10,500	2,670	—	—
42	Phenol		94.1	359	—	—	1.071 [at 77°F. (Solid)			3.248	—	—	—	—	—
43	Water		18.0	212	328	467	1.000	10	8.33	0.622	175.0	—	—	—	—
Miscellaneous gases														**Miscell. gases**	
44	Air		29.0[6]	—	—	—	—	—	—	1.000	—	—	—	—	—
45	Ammonia		17.0	−28	56	161	0.682 at boiling point			0.596	—	9,670	441	—	—
46	Carbon monoxide		28.0	−313	—	—	0.814 at 320°F.			0.967	—	4,347	322	—	—
47	Carbon dioxide		44.0	−109 (Sublimes at)		—	Sublimes at −109 °F.			1.528	—	—	—	—	—
48	Chlorine		70.9	−30	—	—	1.56 at boiling point			2.449	—	—	—	—	—
49	Hydrogen		2.016	−423	—	—	0.07 at boiling point			0.0696	—	61,100	325	—	—
50	Hydrogen sulphide		34.1	−75	—	—	0.79 (approximate)			1.190	—	7,100	647	—	—
51	Nitrogen		28.0	−320	—	—	0.808 at boiling point			0.972	—	—	—	—	—
52	Oxygen		32.0	−297	—	—	1.14 at boiling point			1.105	—	—	—	—	—
53	Sulphur dioxide		64.1	14	110	—	1.460 at boiling point			2.264	—	—	—	—	—

[1] Values extrapolated beyond the critical point.
[2] Liquid under pressure higher than vapor pressure at 60°F.
[3] Research method.
[4] Line 17 refers to "iso-octane" used as a standard in fuel testing. Organic chemists apply the same name to 2 methylheptane.
[5] Gas volume refers to dry basis at 60°F. and 30 in. Hg. For gas saturated with water at same condition deduct 1.73% from heat of combustion per cu. ft.

—From Foster Wheeler Corporation Bulletin O-42-1.

Jones & Laughlin Supply Company stores . . 62 of them east of the Rockies . . . can be as indispensable to a man in the oil or gas business as dogs to a bird hunter.

line to resist knocking. Superabundance of natural gasoline stimulated further research into the effect of volatility on the knock characteristics of motor fuel, the result of which investigation was an extended use of the so-called natural gasoline and the birth of a new problem, vapor lock. The use of natural gasoline as a blending agent for the improvement of volatility was successful, inasmuch as the anti-knock value was increased, but the volatility improvement had been made on the wrong end of the distillation curve. Vapor lock, then, forced an altered vapor pressure specification, a rise in boiling points from the initial to the 35 per cent points and a considerably lowered 90 per cent and endpoint.

The endpoint had formerly been about 400° to 410° but of late years, until military demands took charge, it was found that an endpoint of 360° to 380° was very much better for anti-knock characteristics. In fact, the writer, with his "loping laboratory," has found that of two gasolines, one of 360 endpoint and the other of 400 endpoint, and of practically equal ASTM octane numbers, the one with the lower endpoint showed markedly less tendency to knock in actual road service than the other. When war demands made necessary a return to higher endpoint and somewhat lowered octane ratings, our engines knock more than is accounted for by the relatively slight reduction in arbitrary octane number.

Gasoline of the Future

A gasoline of high octane value does not, in itself, create any higher combustion pressure than one of low octane rating. The purely combustion pressure is a function of the compression pressure, but the explosion pressure, developed by the low octane fuel and causing the knock, certainly can be expected to be much higher than the normal combustion pressure, else there would be no knock. Compression pressures can and do vary considerably, depending on the barometric pressure, actual intake manifold pressure, engine speed, compression ratio, etc., and, theoretically, the combustion pressure will be approximately four times the compression pressure. A number of engine variables influence this relation: The density of the charge, the air-fuel ratio, the crankshaft angle at which ignition occurs, the valve timing, etc. As a result a generalization is almost impossible, but automotive engine designers have done their work so well that the change in relation with different engines under similar conditions is slight.

The octane number of the fuel, in itself, has no direct relationship to the normal combustion pressure. By normal combustion pressure is meant non-knocking combustion. As the octane number of the fuel increases, it is possible to advance the spark toward maximum power. This increases the part of the combustion pressure that is within the normal combustion range, but decreases the part that has herein been defined as explosion pressure.

For any given spark advance, as the anti-knock quality of the fuel decreases, the knocking tendency of the engine increases. In knocking, combustion pressures rise to a much higher level than in normal combustion, but the exact extent will depend upon the degree of knocking, the quantity of the charge that is burned during knocking, rather than in normal combustion, the design of the combustion chamber, etc. In a well known aircraft engine, normal combustion pressures are of the order of 1500 lb. per sq. in., but under severe knocking conditions the total combustion pressure rises to about 5000 lb. per sq. in. It should be noted that the non-knocking combustion pressure of 1500 lb. per sq. in. arises not entirely from compression ratio but from some degree of supercharging. The foregoing seems sufficient answer to the "tremendous combustion pressures" bogey.

In an engine of 5 to 1 compression ratio the compression pressure at 1000 r.p.m. is about 115 lb. per sq. in. and

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consequently the combustion pressure lb. per sq. in. arises not entirely from compression ratio but from some de- would be about 460 lb. per sq. in. If the compression ratio is 7 to 1 the combustion pressure becomes 720 lb. per sq. in. When these figures are turned into total pressure over the area of a piston of given size it is easy to realize the tremendous increase in power per cubic inch of piston displacement made available by the higher compression ratio. One should, however, deduct from the gross power figure the increased power required to meet the increased compression pressure in an opposed cylinder. This is not a large deduction and affects the total only relatively but, in the interest of clarity, it is mentioned.

The potentially destructive effect of the explosion that occurs in the latter phase of the combustion cycle with a high compression ratio, together with high heat so generated, makes necessary the use of a fuel of high octane number in order to realize the advantage of the higher compression. Some of the earlier attempts to ameliorate this knocking consisted of using aluminum and/or copper alloys for the cylinder head. This was effective in reducing the audible evidence of the knock and in dissipating some of the surplus heat of the explosion, by radiation to the air and the circulating water, but the hammer-blow effect on bearings and rods remained. It is understood that, through herculean efforts, the aluminum shortage is about to become a surplus. As an entirely natural result of this there may be active stimulation in fields of usefulness of aluminum and its merits may be extolled as a knock suppressor. Light weight and high heat transfer rate will be sufficient to justify increasing use of aluminum alloys in automotive equipment.

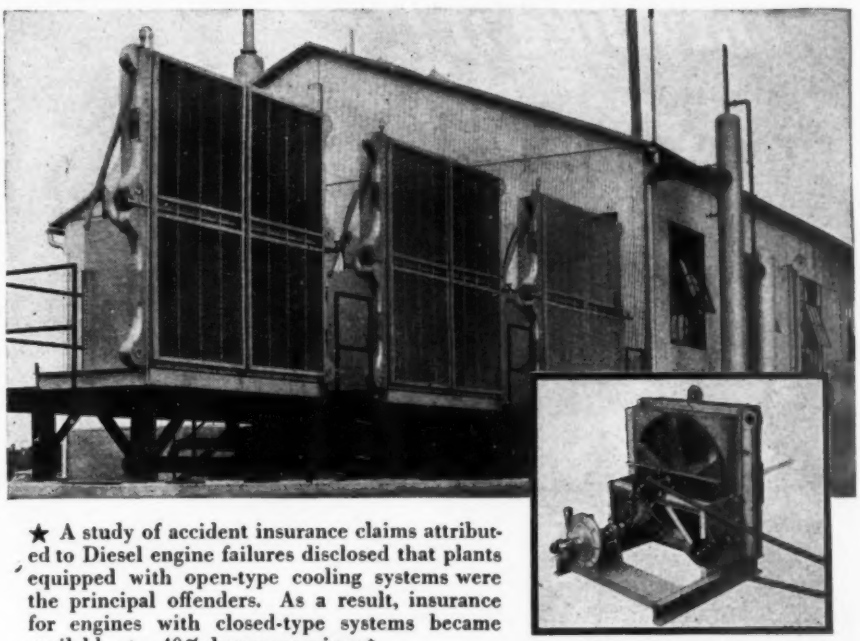
How volume demand for gasoline is likely to be affected by improved engines. There has never been a time in the history of the petroleum industry when the volume demand for gasoline has suffered because of improved efficiency of the equipment using it. Improved equipment simply widened its own use with the inevitable result that the demand for its fuel was stimulated. This has been true of other industries as well, and the only factor likely to change it will be exhaustion of irreplaceable natural resources.

Some of the economic thinking on the subject of supply and demand of petroleum products has been of a weird variety. For example, some oil men have been much concerned in the past over the increasing use of diesel engines without apparently giving any thought to the idea that the compression-ignition engine became popular because it offered, under some circumstances, a more efficient transportation implement than the gasoline engine. One of the important factors in this better efficiency was the low cost of the fuel, which in turn was due to low market demand. As soon, however, as increased use of the diesel engine power unit was reflected in greater demand for suitable fuel for it, the price of the fuel went up and the comparative efficiency in dollars went down. This is certainly the simplest of economics and the sooner the industry realizes the force of it and projects its operations accordingly, the better for everyone concerned. Leaving use of such terms as "dream engines," "special chemicals," and "prohibitive costs" to those who prefer them, this and subsequent articles will be devoted to serious discussion of ways and means whereby refinery operations can be carried on with maximum net profit, no matter what angles the market may take.

The Composite Picture

It is not intended that the accompanying simple diagram serve as a flow sheet of a refinery. Its purpose will have been served if, by study of it, the accompanying characteristics schedule, and the explanations offered, the reader obtains a general idea of the possibilities for profitable operation by giving more

Closed-Type Cooling Systems Reduced Diesel Insurance 40%



★ A study of accident insurance claims attributed to Diesel engine failures disclosed that plants equipped with open-type cooling systems were the principal offenders. As a result, insurance for engines with closed-type systems became available at a 40% lower premium.*

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Three Master series, model 296 "Full-Flow" Coolers (top photo) serving three 400 hp engine-generator units — for both jacket water, and oil to water heat exchangers in the lube oil system. Standard series, model 32 "Full-Flow" Cooler (inset) showing fan, pump and idler arrangement.

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*Stated in Diesel Power, February 1944 — "Diesel Engine Insurance."

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consideration to comprehensive design aimed at versatility of operation, and less to aiming at a few products that seem to offer the best revenues at the moment. Other articles will analyze more completely each operation in the composite picture and will be of interest and value to men who want to arrive at a clearer conception of methods that have been developed for each of the operations shown. Percentages of products recovered are not to be considered as average because an average figure would be of little value to a refiner whose own charge stocks contain the only answer to his specific problems. The percentages to be used are, however, representative of standard conditions in one producing area.

Wet Gas

Wet gas separation and fractionation. There is no other branch of refining that will be more profoundly affected by current and future developments than the one that has commonly been called the natural gasoline industry. The natural gasoline people have suffered for years with the same malady of unbalance between supply and demand as have the other types of processing and the entire oil industry as well. As there was no incentive in the form of increased demand for natural gasoline, only limited research has been done with the idea of increasing recovery.

Within the last year the situation has become exactly reversed and there exists a greater present and future demand for the potential products to be recovered from wet natural gas than the conventional refining methods of the past can supply. The principal demands have been for blending into aviation gasoline, for dehydrogenation to produce butadiene for rubber substitute, and for use in the manufacture of toluene for explosives. This list does not, by any means, cover the field of potential products, but it will be sufficient for the present purpose. It is significant to note that the total amount of products of wet natural gas currently being used for blending into aviation gasoline is at least equal to the amount used in conventional motor fuel.

There are two elements in the natural gasoline situation that require consideration from a somewhat different viewpoint than that of the crude oil reserves picture. In addition to the known reserves of crude oil, as such, there are enormous reserves of natural gas. The free release of this would not only cause wastage of the components for which there still does not exist full market—methane and ethane—but would rapidly reduce underground pressures, thus sacrificing ultimate recovery of the heavier and more valuable components. Prevention of retrograde condensation by forcing the surplus dry gas back into the producing structure is, of course, the logical answer to this and it undoubtedly receives merited consideration to a much greater degree than it has heretofore. The process is expensive because of the extremely high pressures involved, but the recoveries will warrant the expenditures when suitable fabrication materials again are available.

It further will be realized that more complete recoveries of desired molecular forms from the wet gas are to be obtained by *iso*merization and more precise fractionation, both of which are comparatively simple and well understood processes, requiring no high pressures or temperatures. The writer predicts that the natural gas and gasoline industry is due for some solidly prosperous times, and the units to share in this prosperity are sure to be the ones that permit themselves to see the future clearly and to prepare themselves accordingly.

Disposal of the cuts from the wet gas. The methane and ethane fractions have been turned to heating gas almost entirely. The ethane, for example, can be and is being processed into certain other and more valuable products, but consideration of those will come at a later

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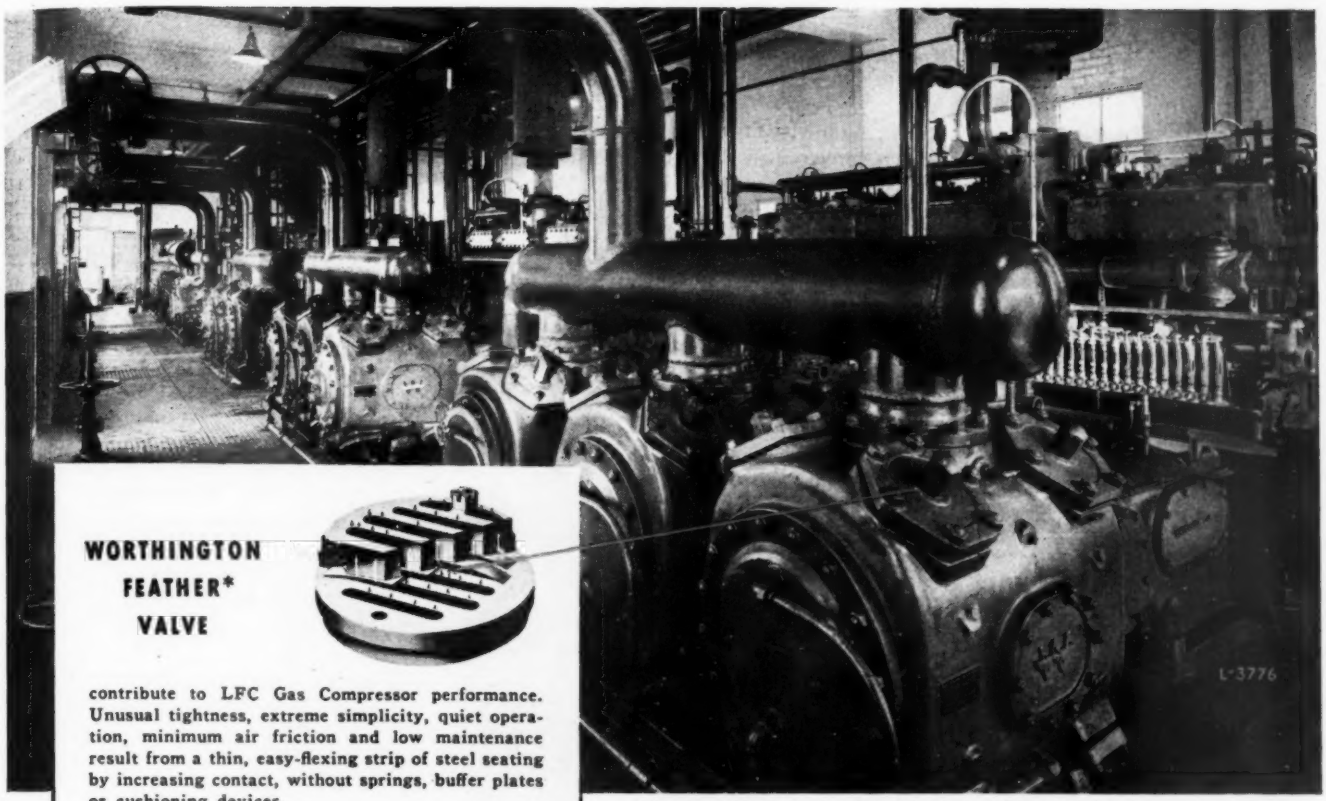

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time. The wet gas, which has been used as a basis for the survey, is presently about 93 per cent in this combined fraction and the dry gas has a gross heating value that can be assessed at 1100 B.t.u. per cu. ft. At the current wholesale price of industrial gas this percentage of 10,000,000 cu. ft. shows a return of about $450 per day, no inconsiderable item.

The propane fraction has, until the last few years, been something of an orphan. When climatic conditions made it feasible, some amount could be permitted to go into the gas mains without undue trouble from condensation at low temperatures. Still more could be mixed with the butanes for pressure-container gas. Propane has a heating value more than twice that of the usual methane - ethane combination, which gave it additional value for industrial gas. Its vapor pressure of more than three times that of the butanes limited the amount, however, that could be used in bottled gas because the trade had become accustomed to a relatively low pressure on the cylinders and feared any rise in that pressure. With the increased demand for butanes for other and more valuable purposes, propane has come into more general use in bottled form. Propane also can be and is being processed into plastics, some forms of rubber substitute, and various other materials. These will be dealt with later. Its content in the wet gas being considered is something like 1.5 per cent.

Butanes

The fact that the branched chain form of butane—*iso*butane—had a considerably better octane number than the straight chain form—normal butane—has been common knowledge for some years but limited use could be made of the knowledge in blending up motor gasoline for octane number because of its high vapor pressure. Therefore, until the advent of the alkylation process for making a high octane blending stock for 100 octane number aviation gasoline, the surplus of both *iso* and normal butane, which could not be absorbed in motor gasoline, was dumped into bottled gas.

With the present enormous demand for aviation gasoline it has become necessary to segregate the two forms, but even this does not meet the requirements for *iso*butane for charging to the alkylation process and considerable amounts of normal butane are being *iso*merized. It is now generally considered that the catalytic process of *iso*merization is completely satisfactory and it is in wide use. Conversions of about 75 per cent are the regular order. The conversion for single pass in something like 40 per cent, making the operation very flexible in final proportions, according to varying demands for volatility correction of motor gasoline, pressure container gas, and alkylation charge stock.

Pentanes

Although the octane numbers of either the *iso* or normal forms of pentane are not so high as the butanes, there is a wider spread between them, some 30 numbers, and, because they have lower vapor pressure than butane, the *iso* form can be used in limited amounts in aviation gasoline and more liberally in motor gasoline where the high octane number, 89, is particularly effective. The separation of *iso* from normal pentane can be accomplished by fractionation but, as there is only 15° difference in their boiling points, it requires somewhat more precise methods. This is not to be feared, however, as methods for precise fractionation are readily available without the necessity for an undue number of trays or the circulation of enormous quantities of reflux. Pentane *iso*merization is also practiced, but not in the degree of butane *iso*merization, as the need is not so great.

(EDITOR'S NOTE: Part 2 of this article will appear in an early issue.)

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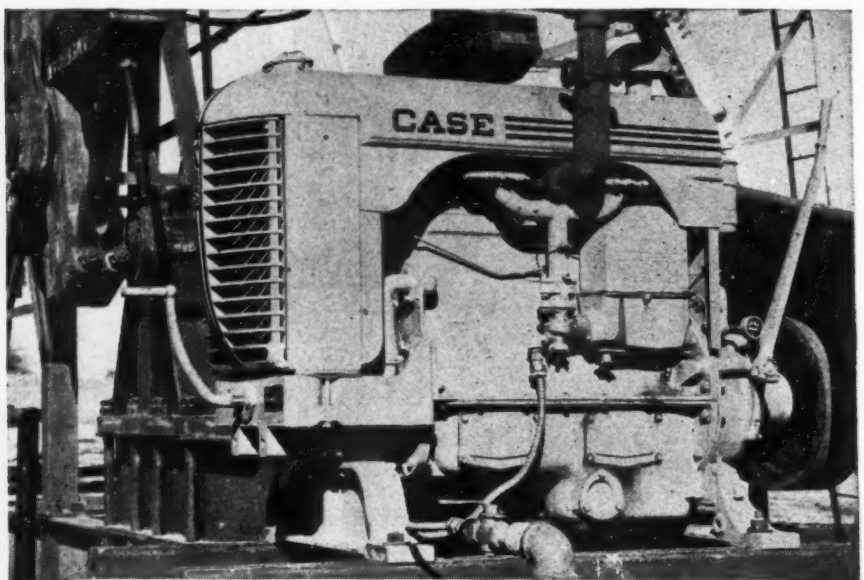

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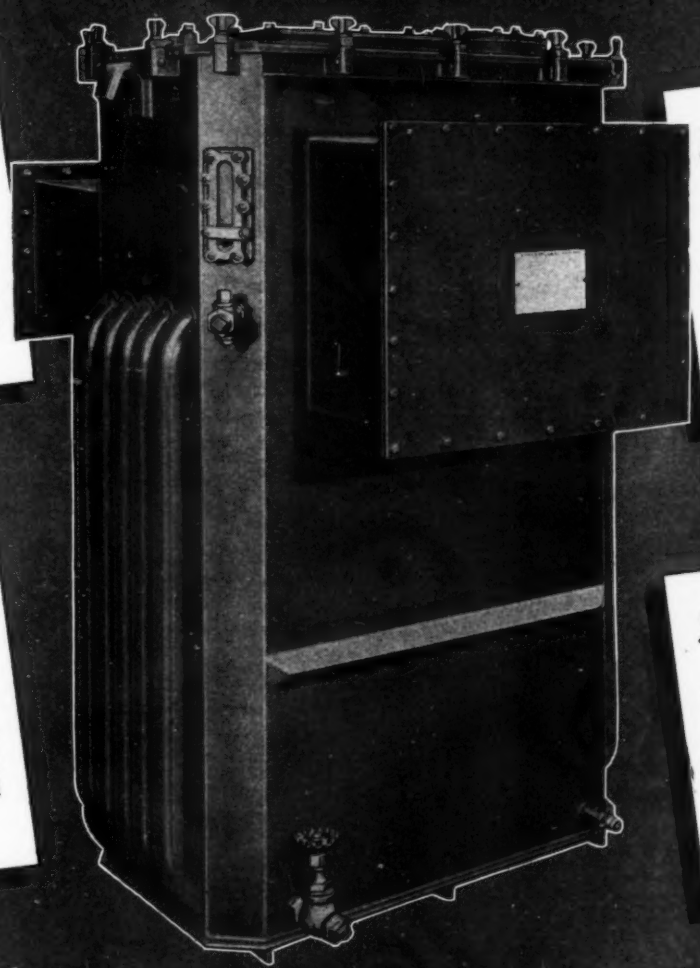

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Treatment of Gas Sands

☆ Field tests indicate harmful effects of water may be avoided by injection of certain fluids

by K. J. Sonney and Charles E. Williams

United Natural Gas Company

AS has been pointed out in another article*, laboratory experiments indicate that the harmful effects of of water on gas sands may be alleviated or avoided by the injection of certain fluids into the sand. Sands previously flooded with water were treated separately with alcohol, acetone, and acetone plus 10 per cent ether, and it was found that each hastened the removal of water from the sand pores. Further, when it was desired to kill a well entirely, other substances than water were used, thus preventing the harmful effects associated with water on the sand.

Some past experiences showing that the existence of this problem has long been recognized by natural gas well operators are indicated by the following tabulation:

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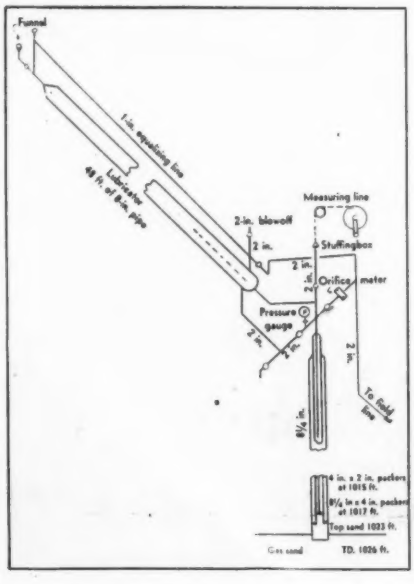
Fig. 1. Sketch of connections at well No. 4170



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After this experience, laboratory experiments by a United Natural Gas Company research employee in conjunction with research workers at the petroleum production research laboratories of The Pennsylvania State College were conducted.

In order to test the laboratory findings in the field, several tests were undertaken and it is the purpose of this article to describe these tests and show some of the results obtained.

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A diagram of the well connections and the lubricator is shown as Fig. 1. A lubricator was necessary as the well had a flow of approximately 1,060,000 cu. ft. per day through 2-in. tubing with a closed-in pressure of 223 lb. gauge, making it impossible to inject liquid into the well without the aid of equipment such as a pump or lubricator. The lubricator was arranged with "swings" at the wellhead, which permitted the free end to be raised or lowered for filling and emptying, and permitted the liquids to be collected and saved for future use.

The general procedure was to fill the lubricator with the liquid to be injected while the lubricator sloped downward toward the well. With the well closed in, the valve from the lubricator was opened and the liquid permitted to flow by gravity into the tubing. When sufficient liquid had been injected into the well to kill it, the pressure gauge on the wellhead read zero. The liquid level in the well was determined by means of a wooden float attached to a measuring line lowered into the well through a stuffingbox.

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Butane, 20 to 25 per cent.
Pentane, 50 per cent.
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Initial boiling point, 55°.
Endpoint, 350°.

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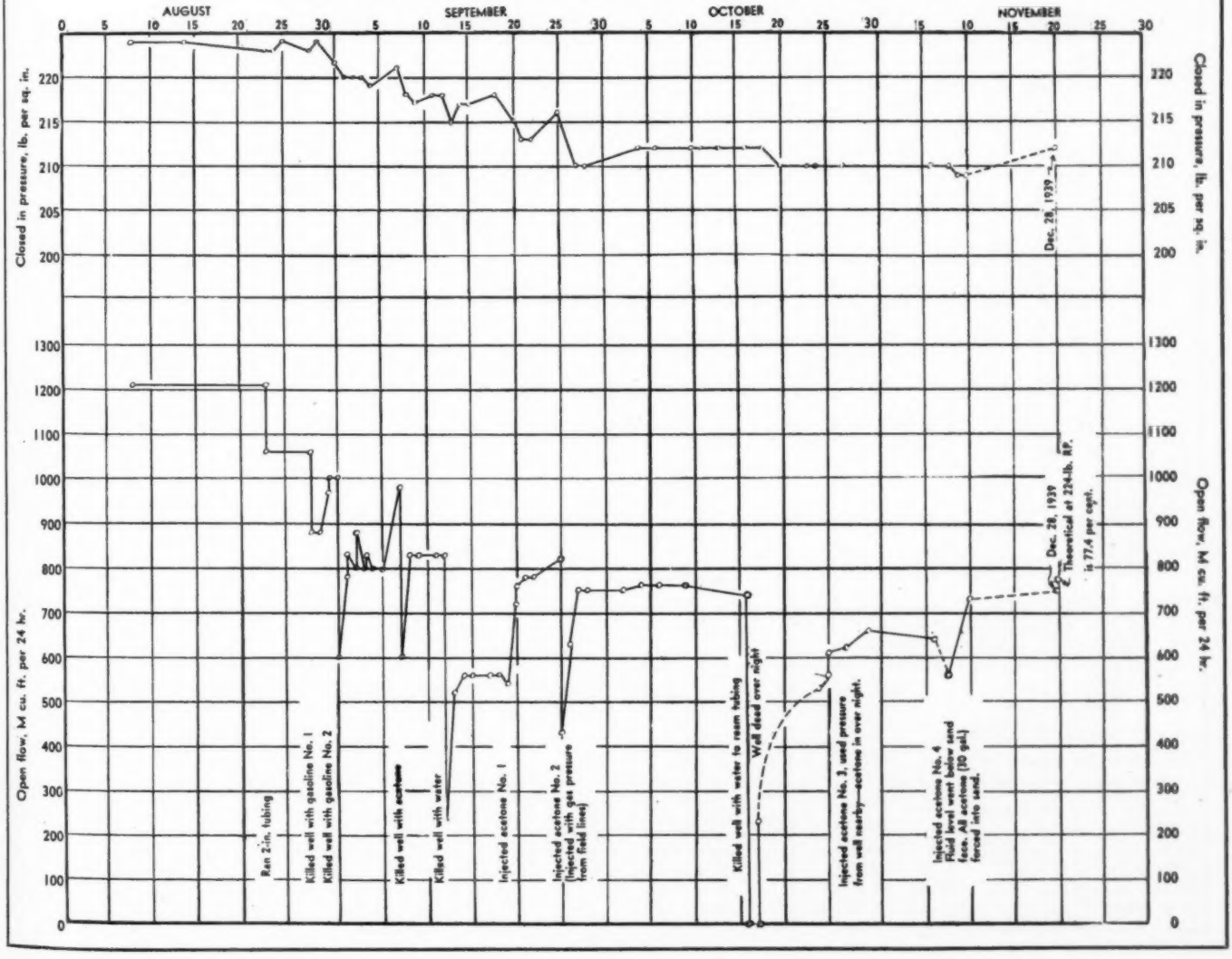
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Closed in pressure, lb. per sq. in.
Open flow, M cu. ft. per 24 hr.
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Killed well with gasoline No. 2
Killed well with acetone
Killed well with water
Injected acetone No. 1
Injected acetone No. 2 (Injected with gas pressure from field lines)
Killed well with water to ream tubing
Well dead over night
Injected acetone No. 3, used pressure from well nearby—acetone in over night.
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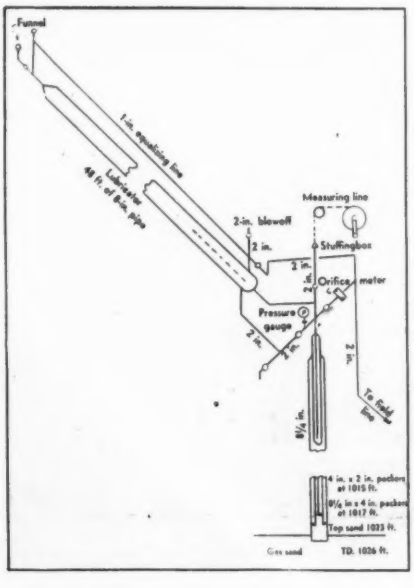

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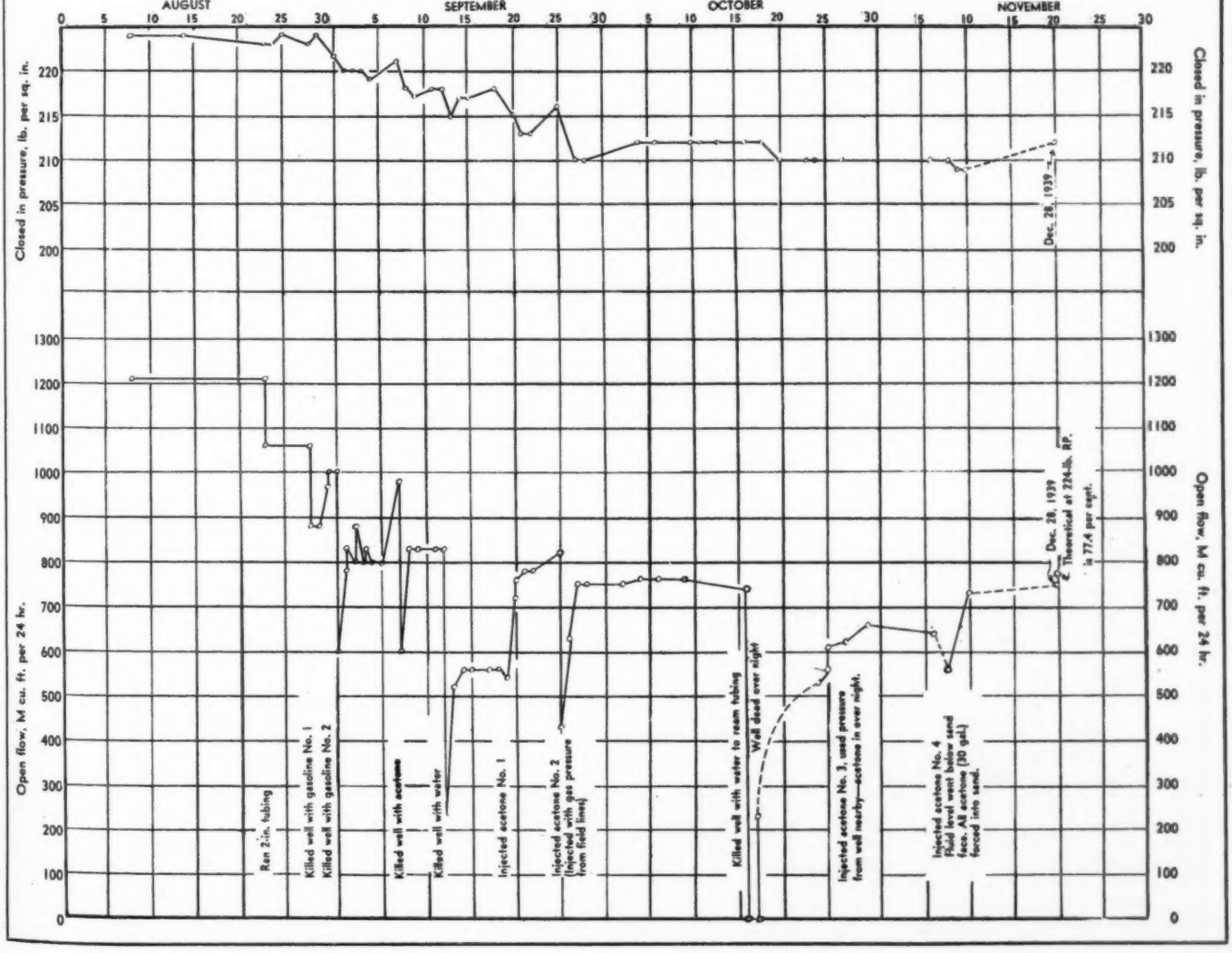
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TABLE 1
Killing and reclamation tests, well 4170

Operation	Date: Start			Date: Finish			Total time elapsed: Days	Hr.	Min.	Closed in press.	Open flow MCF per day: Start	Finish	Gal. fluid into sand	Per cent change in open flow: From previous	From original
Well completed and tubed with 2-in. tubing	..	..	..	8	23	39	..	..	..	223		1060	..	....	....
Killed flow with gasoline-well open to air	8	28	39	8	28	39	..	6	08	223	1060	0	22	100	100
Well producing into line	8	29	39	8	30	39	..	21	24	225	880	1000	..	— 5.7	— 5.7
Killed flow with gasoline-well open to air	8	31	39	8	31	39	..	..	55	....	1000	596	?	—40.4	—43.8
Shut in during days—flowing through nights	8	31	39	9	7	39	7	..	..	221	596	988	..	+65.7	— 6.8
Killed flow with acetone-well open to air	9	7	39	9	7	39	..	3	07	221	988	599	15	—39.4	—43.5
Shut in during days—flowing through nights	9	7	39	9	12	39	5	..	..	218	599	825	..	+37.9	—22.2
Killed flow with water	9	12	39	9	12	39	..	5	48	....	825	0	16.6	....	....
Shut in during days—flowing through nights	9	12	39	9	18	39	6	..	..	218	230	563	..	—31.8	—46.9
Injected acetone to overcome effect of water	9	18	39	9	19	39	..	20	10	....	563	0	48.8	....	....
Shut in during days—flowing through nights	9	19	39	9	25	39	6	..	..	216	540	815	..	+44.8	—23.1
Injected acetone into sand	9	25	39	9	25	39	..	3	..	....	815	430	36.1	—52.7	—59.4
Shut in during days—flowing through nights	9	25	39	10	16	39	21	..	..	....	430	738	..	+71.6	—30.4
Killed flow with water	10	16	39	10	17	39	..	22	37	....	738	0	?	....	....
Shut in during days—flowing through nights	10	17	39	10	24	39	7	..	..	....	232	529	..	—28.4	—50.2
Injected acetone and left in sand over night	10	24	39	10	25	39	..	21	17	....	529	605	33.4	+14.4	—42.9
Shut in during days—flowing through nights	10	25	39	11	6	39	12	..	..	....	605	658	..	+ 8.8	—38.0
Injected acetone and followed up with gas into sand	11	6	39	11	6	39	..	6	12	....	658	....	30	....	....
Shut in—no flow either into or out of sand	11	6	39	11	8	39	1	17	..	210		555	..	—15.6	—47.7
Shut in during days—flowing through nights	11	8	39	11	10	39	2	..	..	....	555	725	..	+13.1	—31.6
Well shut in	11	10	39	12	28	39	48	..	..	212	725	745	..	+ 2.8	—29.7

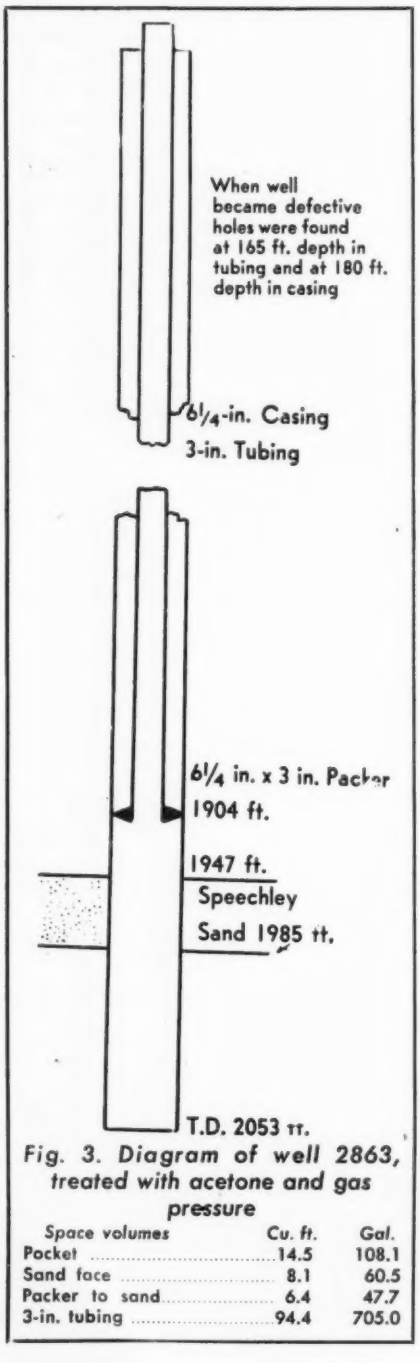
When well became defective holes were found at 165 ft. depth in tubing and at 180 ft. depth in casing
6¼-in. Casing
3-in. Tubing
6¼ in. x 3 in. Packer
1904 ft.
1947 ft.
Speechley
Sand 1985 ft.
T.D. 2053 ft.

Fig. 3. Diagram of well 2863, treated with acetone and gas pressure

Space volumes	Cu. ft.	Gal.
Pocket	14.5	108.1
Sand face	8.1	60.5
Packer to sand	6.4	47.7
3-in. tubing	94.4	705.0

TABLE 2
Reclamation tests, well 2863

Date	Operation	Total fluid injected, gal.	Gas injected, cu. ft.	Computed penetration of fluid, ft.	Well delivery capacity, cu. ft. per day	Injection and shut in press., lb. per sq. in.
6- 8-39	Well tender reports well o.k.	..	..	..	3500	..
6-15-39	Well tender reports well drowned out	..	..	..	0	..
6-27-39	Bailed 1290 gal. water from well	..	..	..	0	..
7- 5-39	Ran 4½-in. tubing and packer over existing 3-in.; bailed 1060 gal. water from well	..	..	..	0	..
7-18-39	Pulled tubing and casing. Tubing failed at 165 ft. Casing at 180 ft. Bailed 120 gal.	..	..	..	..	..
	Repaired tubing leak and tubed well with 3-in. tubing	..	..	..	500	..
10-20-39	Injected acetone, loading fluid with field line pressure	..	..	..	..	59
10-27-39	Injected acetone, loading fluid with field line pressure	35.7	..	0.85	..	66
10-31-39	Bailed well dry and left it open to atmosphere	..	..	..	..	..
11- 6-39	Bailed well dry and left it open to atmosphere; removed 15 gal.	..	..	..	..	..
11-13-39	Bailed well dry and left it open to atmosphere; removed 7 gal.	..	..	..	..	..
4- 3-40	Bailed well dry and left it open to atmosphere; removed 68 gal.	..	..	..	..	..
4- 4-40	Fed gas into well from high pressure main line	..	..	..	..	136
4- 5-40	Main line pressure on well	..	0	..	..	118
4- 8-40 4-19-40	Main line pressure on well	..	14,500	..	..	Avg. 116
4-19-40 5- 1-40	Main line pressure shut off and pressure obtained from high pressure well on system	..	14,800	..	..	Avg. 157
5- 1-40	Turned off high pressure from well	..	..	..	..	..
5- 2-40	Obtained open flow	..	..	..	500	..
5- 6-40	Injected acetone loaded with gas pressure from high pressure well on system	102	..	..	..	122
5- 7-40	Injected acetone loaded with gas pressure from high pressure well on system	159	..	..	..	125
5- 8-40	Injected acetone loaded with gas pressure from high pressure well on system	193	..	..	..	140
5- 9-40	Injected acetone loaded with gas pressure from high pressure well on system	233	..	..	..	100
5-10-40	Injected acetone loaded with gas pressure from high pressure well on system	237	..	..	..	121
5-11-40	Injected acetone loaded with gas pressure from high pressure well on system	244	..	1.5	..	111
5-11-40 8- 3-40	Attempting to force fluid into sand with pressure from adjoining well	..	51,770	16.4	..	Avg. 143
8- 5-40	Forcing fluid back into sand with gas from compressor	..	3,564	21.5	..	..
8- 6-40	Forcing fluid back into sand with gas from compressor	..	11,705	23.0	..	Max. 333
8- 7-40	Feeding gas from well into line; removed 1578 cu. ft.	..	..	..	..	2
8- 8-40	Forcing fluid back into sand with gas from compressor	..	20,880	25.1	..	Max. 378
8- 9-40	Well shut in to equalize pressure	..	..	26.7	..	..
8-10-40	Forcing fluid back into sand with gas from compressor	..	8,960	27.3	..	Max. 342
8-10-40 8-14-40	Well shut in to equalize pressure	..	..	29.3	..	Min. 86
8-14-40 8-27-40	Feeding gas from well into line; removed 27,300 cu. ft.	..	..	25.3	..	2
8-27-40 8-30-40	Forcing fluid back into sand with gas from compressor	..	35,309	37.8	..	Max. 347
9-10-40 9-11-40	Feeding gas from well into line	..	..	..	2420	2
10-11-40 10-22-40	Well shut in for pressure test	..	..	..	..	Max. 80½
10-29-40	Open flow test	..	..	..	2400	..
11-16-40 11-30-40	Well shut in for pressure test	..	..	..	..	Max. 79½

(Continued on Page 98)

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(Continued from Page 94)

accompanied the acetone removed from the well. Perhaps the contaminated acetone may account for the apparent ineffectiveness or relative inefficency of some of the treatments.

Second Unplugging Test

The well was again killed with water and upon revival came back with an open flow of 529,000 cu. ft. per day. A single injection of acetone, which remained on the sand overnight, brought the flow up to 658,000 cu. ft. per day. A second injection of acetone, which was loaded and followed into the sand with gas from a higher pressure well, increased the open flow to 725,000 cu. ft. per day. This was within 2 per cent of the open flow of the well immediately before killing with water the second time. The treatments with acetone indicate that results in the field are in accord with those obtained in the laboratory; further, added benefit may be obtained by following the acetone into the sand with gas.

It will be observed that the open flow at the end of the tests was 745,000 cu. ft. per day, which is a net decrease of 29.7 per cent from the open flow before the tests were begun. Some of this decrease in flow is due to the decline in shut-in pressure of the well. After correcting for decline in shut-in pressure, the open flow at the end of the tests would be approximately 972,000 cu. ft. per day, which is a net decrease of 22.7 per cent from the theoretical open flow.

Treatment of Well No. 2863

Well No. 2863 (Fig. 3) had been flooded by a great head of fresh water and was completely drowned out. The water had been in contact with the producing sand for about one month. Under normal operations the well produced an extremely small volume of gas, from a tight sand, and in an area where the formation pressure was only about 80 lb. gauge.

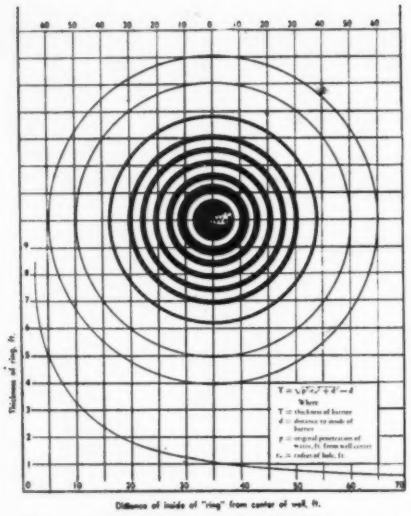


Fig. 4. Hypothetical thickness assumed by water barrier at various distances from gas well. Scale: ½ in. = 10 ft.

After repairs had been made to the tubing, the open flow was only 500 cu. ft. per day. It was selected for treatment because of the experimental results to be expected rather than the economical benefits to the low volume well. Due to the pressure and permeability of the producing sand, a different procedure was required at this well although the principle of following the acetone into the sand with gas, which was beneficial at well No. 4170, was considered advisable to follow.

A simple calculation can be made to show the action that should take place in such a process. If it be assumed that the water that damaged the well penetrates the sand evenly in all directions, it will spread in a ring whose center is the well. When gas is injected, it will push the water back into the sand and the ring will diminish in thickness according to the equation as shown by the diagram Fig. 4:

$$T = \sqrt{P^2 - r_w^2 + d^2} - d$$

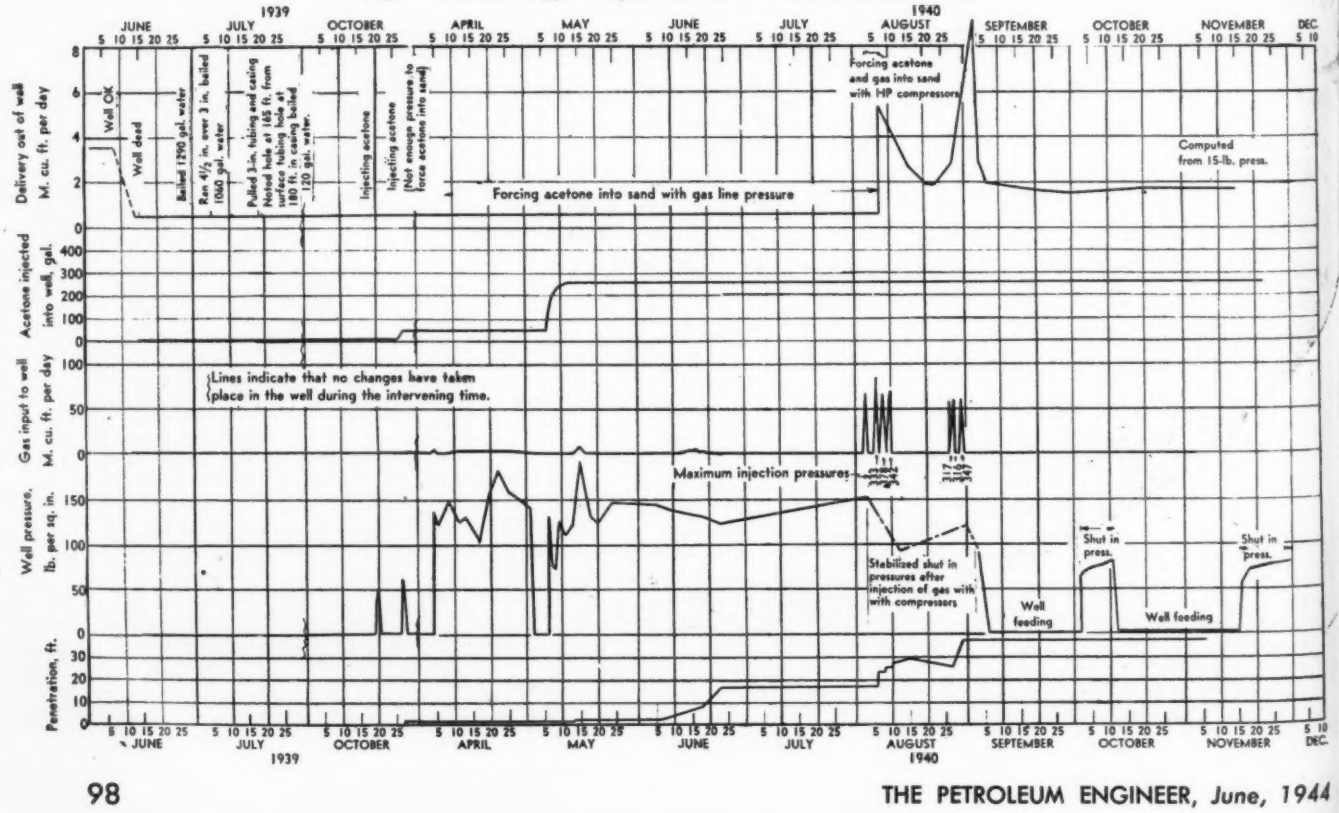
Where:

- T = thickness in feet of the water barrier at any point,
- P = the distance into the sand the water had originally penetrated, measured in feet from the well center,
- r_w = the radius of the well bore, ft., and
- d = distance in feet from the center of the well to the inside edge of the water barrier.

If the ring is pushed out far enough, it will eventually break leaving channels cleared for gas passage. Further, it can be shown that if relatively dry high pressure gas is forced into the well, it will pick up fluid vapors in expanding from the injection pressure to the formation pressure; also, in expanding from the formation pressure to the lower well pressure when the flow is reversed and the well is placed on production. If the water in the sand were previously diluted with acetone, it

(Continued on Page 101)

Fig. 5. Chronology of operations, well 2863 reclamation


1939
1940
JUNE
JULY
OCTOBER
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DEC.
Delivery out of well M. cu. ft. per day
Well OK
Well dead
Bailed 1290 gal. water
Ran 4½ in. over 3 in. bailed 1000 gal. water
Pulled 3-in. tubing and casing Notched hole at 185 ft. from surface tubing hole at 180 ft. in casing bailed 120 gal. water.
Injecting acetone
Injecting acetone (Not enough pressure to force acetone into sand)
Forcing acetone and gas into sand with HP compressors
Computed from 15-lb. press.
Forcing acetone into sand with gas line pressure
Acetone injected into well, gal.
Gas input to well M. cu. ft. per day
Lines indicate that no changes have taken place in the well during the intervening time.
Maximum injection pressures
Well pressure, lb. per sq. in.
Stabilized shut in pressures after injection of gas with with compressors
Shut in press.
Well feeding
Penetration, ft.

(Continued from Page 98)

would seem that the maximum benefit could thus be obtained.

Connections were made to high pressure gas lines in the field and, after placing 244 gal. of acetone above the sand, an attempt was made to force the acetone into the sand and follow it with gas. Although the acetone was forced into the sand, it was not possible with the pressure available to obtain sufficient penetration to break down the water barrier. A portable gas compressor, capable of pumping against 500-lb. pressure, was then installed in the system and several injections of gas were made as shown on Table 2 and Fig. 5.

Results from this test show that the barrier was finally broken and that the well is evidently in communication with the rest of the field. The flow has been increased from 500 to 2400 cu. ft. per day. The flow, previous to flooding when computed from the 15-min. rise above line pressure, was 3500 cu. ft. per day. The calculations of the distance the water ring moved indicates that the ring, if maintained in circular shape, broke through at a distance of 37.8 ft. from the well.

These results are very encouraging when the circumstances under which treatment was made are considered. Tests made in June, 1941, and August, 1943, show the well to be about the same as it was previous to treatment, and it has been producing gas into the line continuously since it was treated except for short periods to permit taking pressures.

Killing Well No. 3507

In addition to tests on the two wells as explained above, it has been necessary, in order to repair, to kill a well having an open flow of 380,000 cu. ft. per day and a rock pressure of 655 lb. gauge. Enough acetone was lubricated into the well to cover the producing sands so that the uppermost sand was covered to a depth of 20 ft. The remainder of the hole was then filled with water to a point sufficient to balance the formation pressure. The well was then bridged below the pipe depth but above the producing sands, and was completely dead for a period of 7 days during which time casing repairs were made. After the casing was repaired, the tubing was fished out and the bridge removed. Between 7th and 14th days, the well began gassing slightly but no fluid was added to stop the gas flow. After the well was cleaned out, the fluid removed, and the well put back on production, the open flow was gauged at 346,000 cu. ft. per day, a decrease of only 9 per cent from the flow before killing. This compares with decreases in flow as great as 59 per cent when other wells have been killed with water alone.

Conclusion

The results of these tests substantiate in a way the laboratory findings. It is believed that there is a wider field for the application of this process, and further investigation should yield other suitable materials and methods of application.

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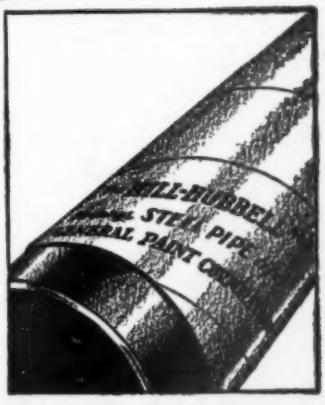

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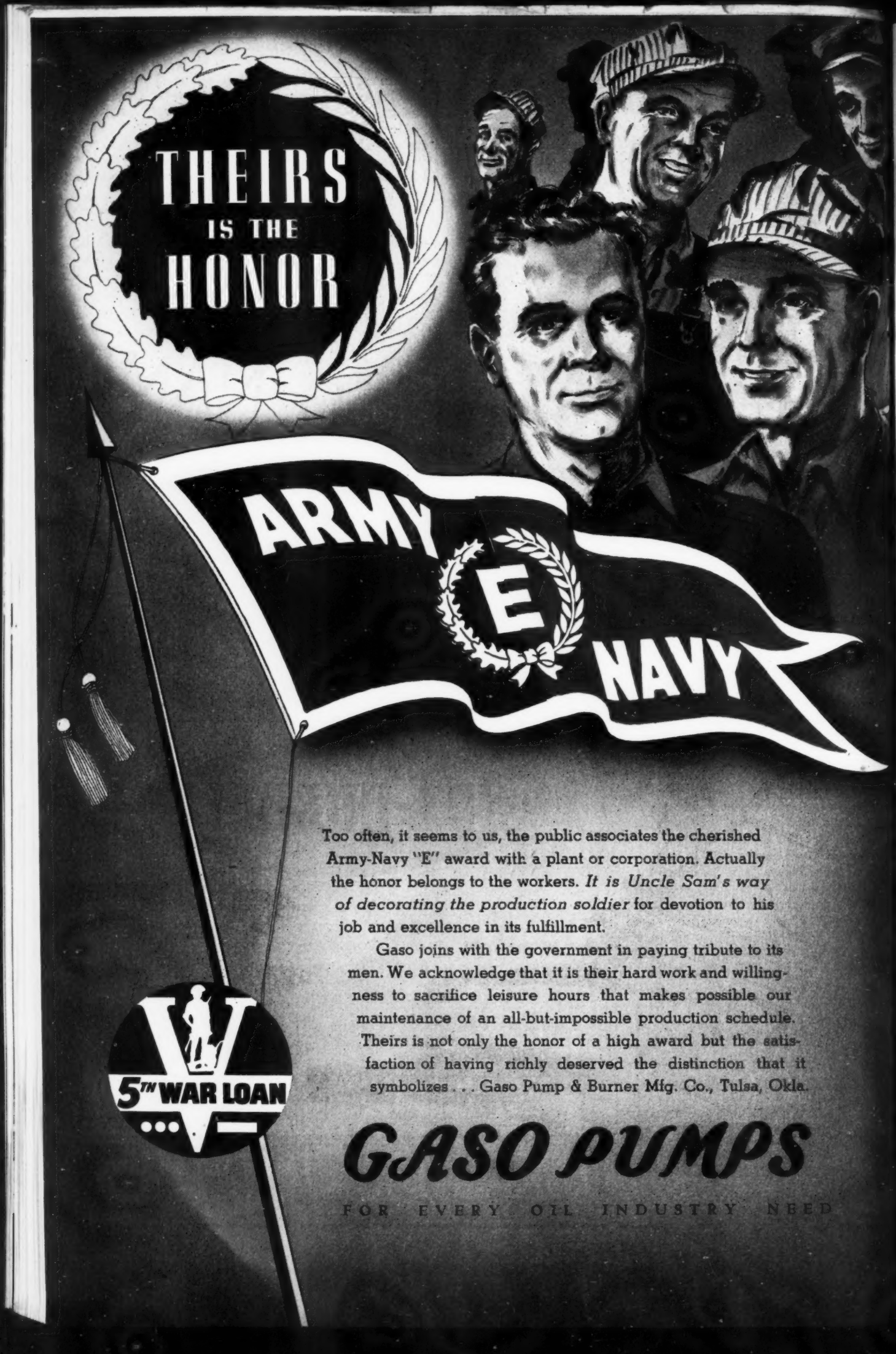

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Corrosion of Buried Metals And Cathodic Protection

PART 4 (Concluded)

by M. C. Miller

Electrical Engineer, Ebasco Services Incorporated

METHODS of determining extent of cathodic protection. The method generally used at present for determining when sufficient external current is applied to a buried metal structure to provide cathodic protection is different for pipe lines than for lead-sheathed cables.

For pipe lines, the protective current is increased until the pipe-to-soil potential is lowered to at least minus 0.8 v. as measured to a copper sulphate reference electrode using a high resistance voltmeter, vacuum tube voltmeter, or potentiometer type voltmeter. These instruments are explained later. This means that the pipe-to-soil potential of the cathodic areas may be lowered from, say, minus 0.5 to minus 0.8 v. and the potential of the anodic areas lowered from say, minus 0.7 to minus 0.8 v. Some engineers prefer to maintain at least minus 0.85 v.

Experience during the last five years or more indicates that when this potential is maintained, corrosion and leaks on pipe lines have been greatly reduced or stopped.

It is realized that this criteria of minus 0.8 or minus 0.85 v. pipe-to-soil potential is not highly accurate but it provides a practical field method.

This criteria of minus 0.8 or minus 0.85 v. does not apply of course to copper or brass pipes, nor to galvanized pipes. Copper or brass pipes generally do not corrode in most soils even though the normal pipe-to-soil potential is about minus 0.2 v. to copper sulphate electrode. The pipe-to-soil potential of galvanized pipe may be about minus 1.1 v. in corrosive soils. To protect cathodically the galvanizing on a buried galvanized metal structure, a metal-to-soil potential of about minus 1.3 to copper sulphate electrode may be required.

For lead-sheathed cables, different methods are used for determining whether the sheath is corroding or is cathodically protected. One method frequently used is to determine whether current flow is from the cable sheath to the adjacent soil; or to the cable from the adjacent soil.

The approximate magnitude and direction of flow of the current is determined by placing a lead electrode in the adjacent soil and connecting it to the cable sheath through a low resistance milliammeter or millivolt meter. If current flows from the cable sheath to the soil, part of it will be shunted through the meter and lead electrode with a positive deflection on the meter. If current flow is to the cable sheath, part of the current will flow to the lead electrode through the meter and to the cable sheath with a negative deflection of the meter, if the positive terminal of the meter is connected to the cable sheath.

If current flow is from the sheath, it is said to be positive to the soil. If current flow is to the sheath, it is said to be negative to the soil. The magnitude generally is expressed in millivolts or volts.

Another method commonly used, sometimes in conjunction with the above, is to measure the potential between the cable sheath and the lead electrode, using a high resistance voltmeter to determine the IR drop in the soil between the cable sheath and soil where the lead electrode is placed; also the direction of current flow. The potential difference provides no indication of the magnitude of current flowing, and used alone may be very misleading. By measuring both the potential and current flow, the approximate earth resistivity may be calculated and a corrosion factor or index obtained. The size and contact resistance of the lead electrode has considerable effect on the amount of current shunted through the meter.

Galvanic potentials between the cable sheath and the lead electrode (because of slightly dissimilar metal, surface films, surface conditions, or different electrolytes) may seriously affect current or potential readings of small magnitude, even resulting in reversal in direction.

Instruments and Equipment

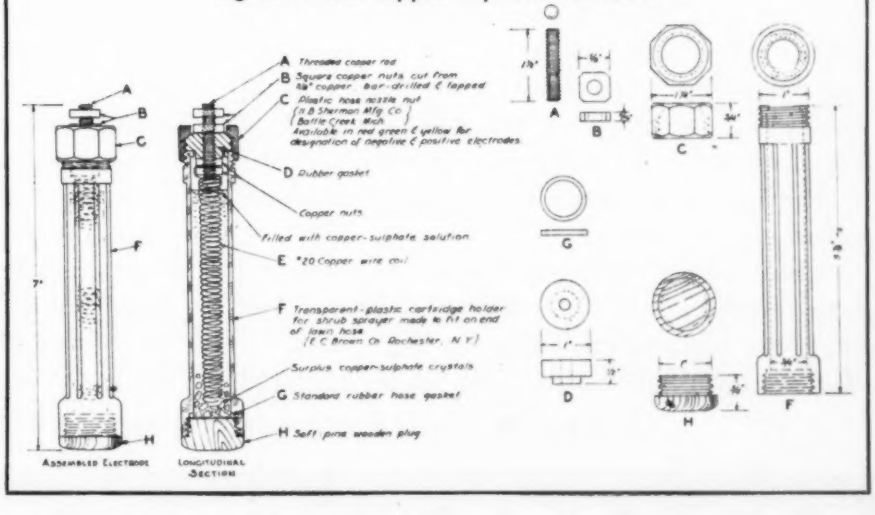
Little can be accomplished in a study or investigation of galvanic corrosion or of electrolysis resulting from stray railway currents or in the application of cathodic protection, without suitable instruments. They are as essential as a knowledge of the fundamentals of corrosion and cathodic protection.

The required accuracy of the instruments depends on whether they are to be used for laboratory or experimental work, or for general field corrosion and cathodic protection measurements and routine periodic checkups where ruggedness with reasonable engineering accuracy usually is desirable.

The following discussion deals with instruments for general field work. There is no desire to indicate preference for instruments of one manufacturer as compared to another, but to discuss desirable characteristics.

Measurement of metal-to-soil potentials. A majority of the potential readings will be from 0.5 to 2.0 v. A multi-range meter is desirable with

Fig. 23. Small copper sulphate electrode


A Threaded copper rod
B Square copper nuts, cut from ¾" copper bar, drilled & tapped
C Plastic hose nozzle nut (H.B. Sherman Mfg. Co. Battle Creek, Mich.) Available in red, green & yellow for designation of negative & positive electrodes
D Rubber gasket
Copper nuts
Filled with copper-sulphate solution
E #20 Copper wire coil
F Transparent-plastic cartridge holder for shrub sprayer made to fit on end of lawn hose (E.C. Brown Co. Rochester, N.Y.)
Surplus copper-sulphate crystals
G Standard rubber hose gasket
H Soft pine wooden plug
Assembled Electrode
Longitudinal Section

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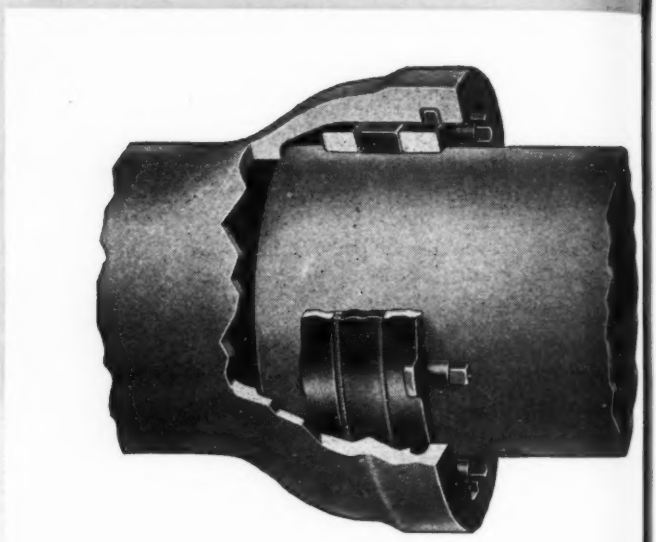

Above you see a workman holding a 6 inch Dresser Bellmaster (weight, 8 lbs.) just as it reached the storeroom—a completely factory-assembled unit, ready for work.

It will take the workman no more than 2 to 5 minutes to make up the permanently tight pipe connection. He has only to wipe out the bell, insert the Joint, wipe and stab in the spigot, and tighten the capscrews with a small wrench. No bell-holes needed.

The cutaway view illustrates the working principle of this new mechanical Joint. A resilient gasket is compressed between two light, strong, malleable rings and against the pipe, by capscrews. This effects a constant, flexible seal, bottle-tight even under unusual conditions of expansion, contraction, deflection and vibration.

Thus effectively the ancient problem of cast-iron pipe joining has been solved. The Joint itself, locked in the bell of the pipe, is safe from attack by corrosion. CIP lines are given new protection from leaks and breaks —new operating efficiency.

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ranges of about 0-0.02, 0-0.1, 0-0.2, 0-0.5, 0.-1, 0-2, 0-5, and 0-10 v. The 0-1 v.-scale will be used the most.

For a direct-reading voltmeter, a high-sensitivity meter, having a minimum sensitivity of 100,000 or 200,000 ohms per volt is desirable. Even higher sensitivity is necessary for accuracy under many conditions. This high sensitivity is required because of the high contact resistance of the copper sulphate electrode with the earth, especially when the earth is dry, such as city streets. This contact resistance is in series with the voltmeter. If a meter with, say, 10,000 ohms internal resistance were used and the contact resistance of the electrode were 5,000 ohms, the voltage reading would be two-thirds the actual voltage. Usually the contact resistance is not known or easily determined. Also, if the resistance of the meter is too low, it will draw enough current to polarize the reference electrode or perhaps actually reduce the voltage of the metal structure if the structure is small.

A meter with a long scale is desirable as many readings need to be taken to three decimal points, such as 0.965 v.

A direct-current vacuum tube voltmeter has been designed for metal-to-soil potential measurements. It has an internal resistance of about 2,000,000 ohms on any voltage range. However, the minimum full-scale deflection obtained (with the basic micro-ammeter used) is 0.1 v. It is more complicated to use than the three models mentioned above, as it is necessary to adjust zero and full-scale deflection frequently.

Some engineers use a potentiometer type voltmeter that draws no current when balanced. It has some advantages and also some disadvantages. For routine periodic checkups a low cost, rugged potentiometer type meter has been developed.

Reference electrodes. For measurement of metal-to-soil potentials, voltage between two points in the earth, and many other corrosion and cathodic protection measurements, a suitable reference electrode for contacting the earth is essential.

Fig. 23 shows a copper sulphate electrode designed for field use. It is low in cost, can be made up from parts procured locally, and assembled by any handyman. Fig. 24 shows a type for use in city work where it is necessary to contact surfaced streets or hard dry soils. Two of each of these are convenient for general field tests.

In assembling these, the copper parts must be thoroughly cleaned and washed. A satisfactory cleaning solution is a 25 per cent solution of nitric acid in distilled water. After cleaning and washing thoroughly to remove all acid, the holder is filled with a saturated solution of high purity copper sulphate crystals in distilled water, with a few surplus crystals to maintain saturation.

The copper sulphate electrode is used extensively in the field for a reference electrode in connection with corrosion and cathodic protection tests on pipe lines and other buried steel and iron structures, and in some cases on cable sheaths. For corrosion and cathodic protection tests on cable sheaths, however, a lead electrode generally is used when current flow in terms of volts is determined rather than sheath-to-soil potential.

The half-cell voltage of the copper sulphate electrode, even when made up in a form suitable for field use, is virtually constant for different types of soil, and with different moisture conditions. It is affected only slightly by temperature changes normally encountered. When used in conjunction with a high resistance type, potentiometer type, or vacuum tube voltmeter, the small amount of current drawn by the meter is not apt to polarize the electrode and change its half-cell voltage if it is suitably constructed and has sufficient area of copper in the $CuSO_4$ solution.

The total resistance of the electrode to earth is an important factor, as it is in series with the resistance of the meter. The total resistance varies over a wide range (from a few hundred ohms to a few thousand ohms) depending on the soil resistivity and whether it is dry or moist. To reduce the resistance where the soil is dry, a cup of water poured on the ground is helpful.

D-c ammeters. For measurement of galvanic currents, and cathodic protection currents from zinc, batteries, rectifiers, and generators, a meter that will measure from a few milliamperes up to 100 amp. is desirable. It should have a low internal or shunt resistance to avoid reducing the current flow.

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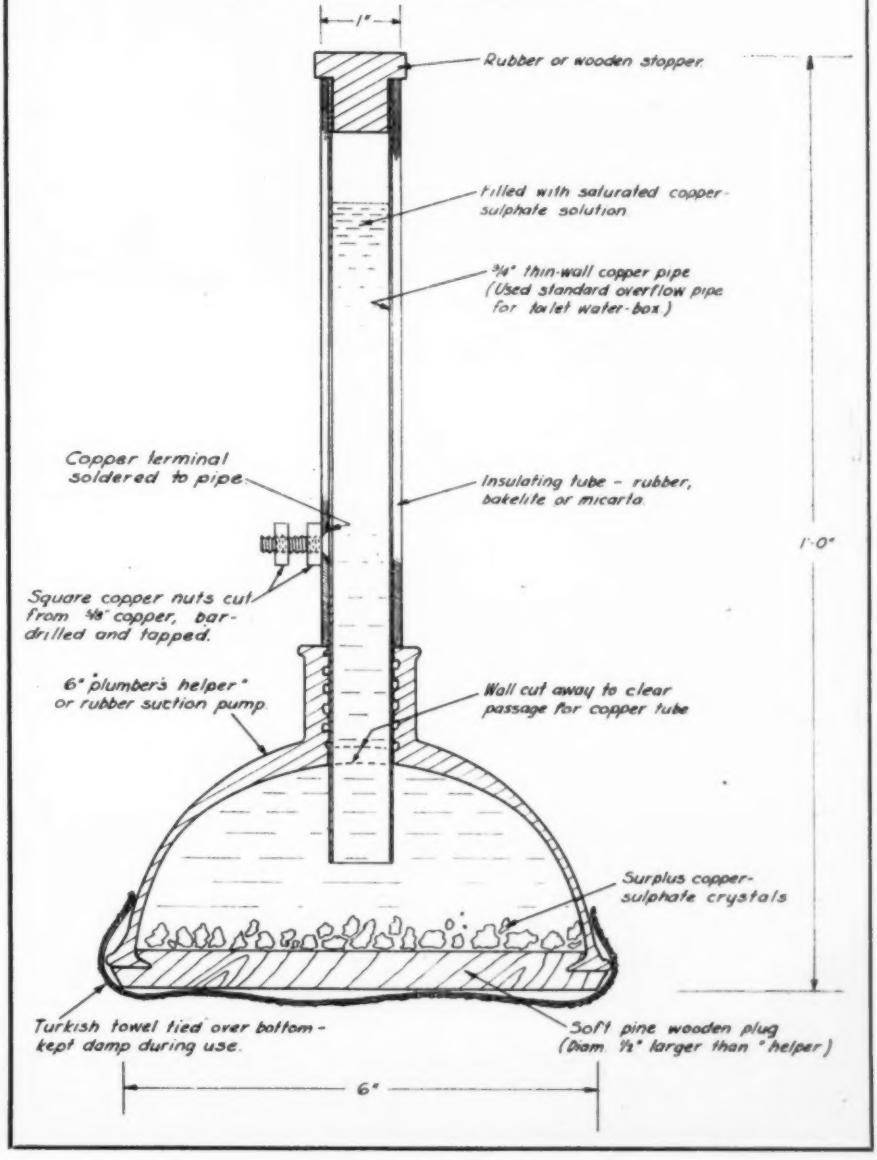
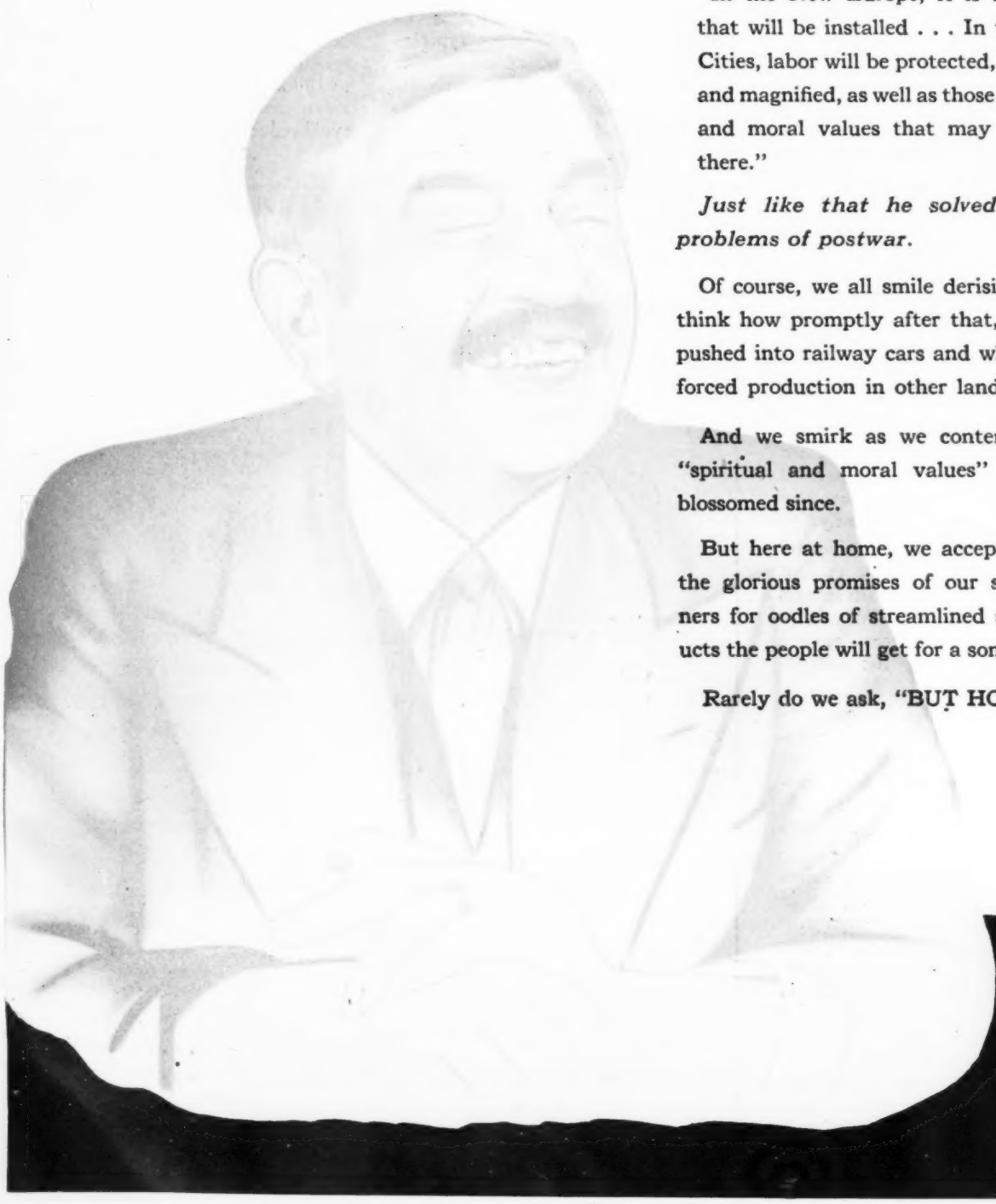
Fig. 24. Large copper sulphate electrode


1"
Rubber or wooden stopper
Filled with saturated copper-sulphate solution
¾" thin-wall copper pipe (Used standard overflow pipe for toilet water-box)
Copper terminal soldered to pipe
Insulating tube - rubber, bakelite or micarta
1'-0"
Square copper nuts cut from ⅛" copper, bar-drilled and tapped.
6" plumber's helper" or rubber suction pump
Wall cut away to clear passage for copper tube
Surplus copper-sulphate crystals
Turkish towel tied over bottom - kept damp during use.
Soft pine wooden plug (Diam. ⅛" larger than "helper)
6"

then he said to himself

"I hope they don't ask me HOW!"



Pierre Laval, on being handed the mouthpiece by Adolf, promptly broadcast to the French people:

> "In the New Europe, it is socialism that will be installed . . . In the New Cities, labor will be protected, honored and magnified, as well as those spiritual and moral values that may blossom there."

Just like that he solved France's problems of postwar.

Of course, we all smile derisively as we think how promptly after that, labor was pushed into railway cars and whisked into forced production in other lands.

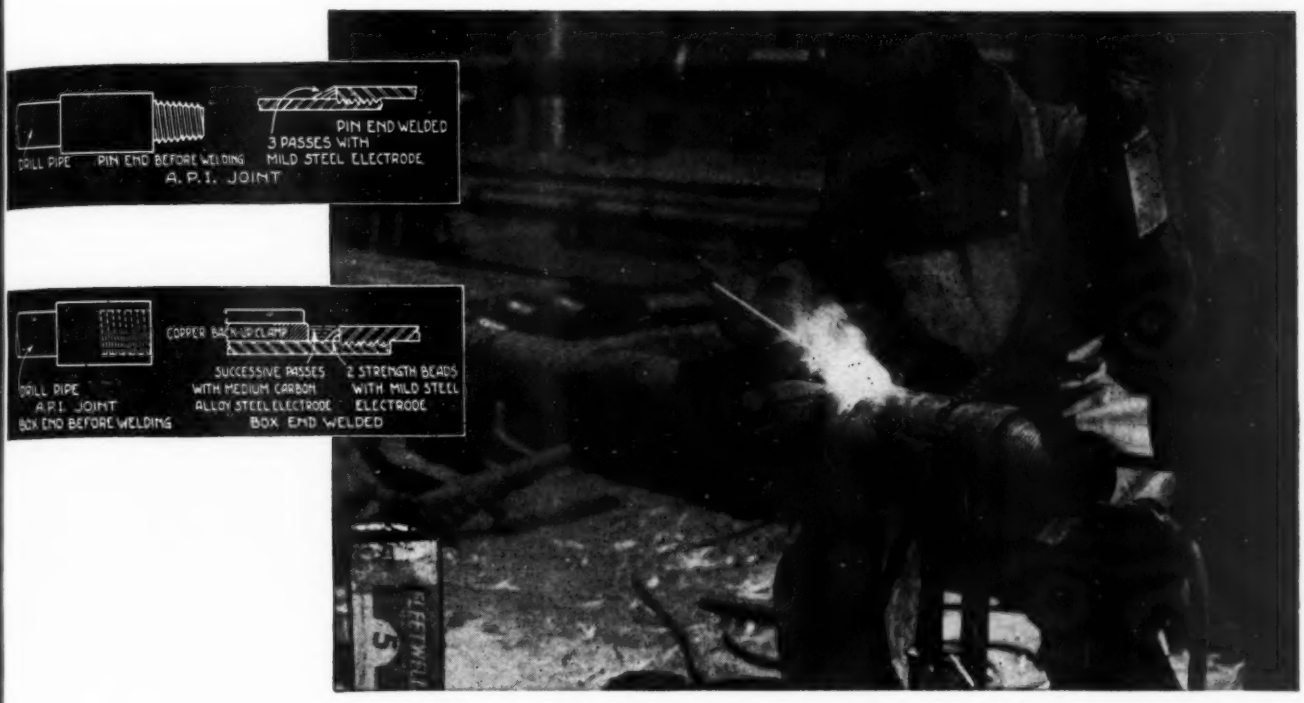
And we smirk as we contemplate the "spiritual and moral values" that have blossomed since.

But here at home, we accept as gospel the glorious promises of our social planners for oodles of streamlined super-products the people will get for a song.

Rarely do we ask, "BUT HOW!!"

"Protected, Honored and Magnified"—*he says*

Look, Pierre, under your own or any *new social order,* a small group of soft-handed *theorists* like yourself could never give a *practical* answer to the challenge: "BUT HOW?" Yet under an old American *free enterprise* system . . . where protection, honor and magnification are in every man's grasp—workmen in most shops and in most fields can themselves answer: *HERE'S HOW!!*



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Box end: Two beads are made first with "Fleetweld 5" electrode for strength. A copper back-up clamp then is used to apply a wear-resisting shoulder with a flat face up to the level of the joint. This weld, made with "Hardweld" electrode, provides a hard, flat surface for contact with the elevator. Back-up clamp is positioned between the clamp and the joint is filled up to the edge of the joint. This is a roll welding operation.

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Have Oil Reserves Been Diminished by Expediency?

PETROLEUM ENGINEER Feature

☆ A look at the trend of events during the last 10 years

by S. F. Shaw
Consulting Engineer

THE status of oil reserves in the United States cannot be viewed with complacency in connection either with war activities or with normal domestic requirements. This is due, it seems to the writer, largely to prices that have been frozen at inadequate levels, which do not attract the wildcatter to drill for oil to the extent that should be the case, nor does it contribute toward the use of methods of drilling, completing, and producing wells in the manner that yields the maximum recovery of the reserves that have been developed. These appear to be the consequences that follow the trend of events that have taken place during the last 10 years or more.

In Table 1 there are presented two sets of estimates of reserves for the years 1943 and 1944 prepared by two different authorities. In this table, reserves are summed up by states and the totals of the two authorities check quite closely; however, this may result from the methods of approach in making these estimates being so nearly alike that they do not allow for possible inaccuracies in analyzing the situation that confronts us.

Estimates of the total petroleum reserves of the United States at the beginning of 1944 are placed at 20,064,000,000 bbl. by the American Petroleum Institute, and at 20,046,000,000 bbl. by the *Oil and Gas Journal*. With figures so nearly identical, we might content ourselves with the feeling that the future reserves of developed fields can be assured at figures close to those stated. For individual states the estimates do not check so closely, although estimates for Texas nearly coincide, and these reserves account for 55 per cent of the total reserves of the United States. It seems to the writer that we should make an anlysis of the individual fields before we arrive at a feeling of satisfaction regarding the degree of dependence that can be placed on these figures notwithstanding the efforts that undoubtedly have been employed to make the estimates as accurate as possible.

In Table 2 there is presented a list of 35 of the principal fields of the United States, which fields account for about 50 per cent of the total estimated reserves of this country. These fields are arranged in the table as of January 1, 1943, in descending order of magnitude of their estimated ultimate recovery. It is very clear that if figures for the large fields are not reasonably correct, the totals for the entire United States would be influenced, and this would be true particularly of revisions of the future reserves of such fields as East Texas, Conroe, Yates, Slaughter, Wasson, Tom O'Connor, Goldsmith, Hastings, and Webster, because from these fields less than 50 per cent of the total estimated recoveries have been extracted. Where the withdrawals of fields have already amounted to 75 per cent or more of the total estimated recovery, it is not likely that the reserves will come up for serious revisions.

In Table 3 there are presented figures in fields in which estimates have reached a peak point and where it is clear that downward revisions were in order. The writer makes no attempt in this article to place estimates on reserves in these various fields. Attempts in the past to arrive at such figures have not been satisfactory whatever may have been the reason. A study of the estimates made in fields by various engineers and geologists compared with figures that afterward became logical when these fields had produced the major portion of their reserves, make it difficult to believe that such estimates can be more than intelligent guesses.

It may be that recovery factors employed in estimating reserves developed since 1930 are influenced too greatly by the factors that were found to apply to estimates made prior to 1930 when oil fields were developed with close spacing, when completion practices were different, and when daily withdrawals were very much greater than during the last 10 years of severely restricted production. Analyses made of these figures during the next 10 or 20 years should provide a much better understanding of estimates based on present day practices.

Comments on some of the fields listed in Table 3 are given in the following paragraphs:

Arkansas. During the last year, estimate of reserves in the Magnolia field has been reduced from 180,000,000 bbl. to 150,000,000 bbl., which is a reduction of approximately 10 per cent of the remaining developed reserves of the entire state. It is possible that later there may be further reductions in this field. In the U. S. Bureau of Mines Report of Investigations No. 3720, recovery in the Magnolia field is placed at 79,760,000 bbl. when using a recovery factor of 40 per cent; with 50 per cent

TABLE I
Reserves in various states of the United States as of 1943 and 1944

State	Reserves in thousands of bbl.				Thousands of bbl. produced, 1943[5]	Ultimate recovery as of January 1	
	A.P.I.		O. & G. Journal[5]				
	1943[4]	1944[4]	1943	1944		1943[6]	1944[5]
Arkansas	300,026	296,929	392,907	367,301	27,606	974,000	970,252
California	3,195,846	3,336,823	3,200,468	2,980,082	284,286	9,248,332	9,354,085
Colorado	39,443	45,111	[1]31,978	30,779	2,431	74,584	105,323
Illinois	306,778	294,622	457,652	415,135	77,637	1,399,870	1,424,817
Indiana	31,773	31,039	32,639	31,696	5,343	177,127	182,209
Kansas	686,975	645,852	974,272	905,145	105,697	2,070,920	2,153,935
Kentucky	34,653	35,190	[2]42,313	45,905	7,908	218,861	230,701
Louisiana	1,442,126	1,483.826	1,183,497	1,073,412	125,780	2,487,853	2,596,325
Michigan	63,843	55,248	100,003	94,768	20,535	260,084	298,700
Mississippi	40,897	38,873	63,381	48,213	18,868	107,031	115,873
Montana	85,558	108,057	109,698	103,317	7,641	188,947	208,850
Nebraska	2,177	1,000	[3]2,795	1,941	854	5,899	6,102
New Mexico	677,497	653,981	606,673	582,049	38,924	994,510	963,840
New York	54,395	90,525	50,037	45,724	4,313	189,860	190,518
Ohio	35,021	32,643	34,848	33,203	3,185	630,164	631,910
Oklahoma	968,927	908,618	1,194,345	1,109,181	120,559	6,206,192	6,316,600
Pennsylvania	153,118	137,323	198,273	181,522	16,751	1,219,665	1,218,350
Texas	11,545,727	11,324,954	11,692,408	11,346,019	589,129	19,492,931	19,542,558
West Virginia	47,187	43,839	37,128	33,970	3,158	454,994	455,085
Wyoming	370,572	499,394	340,329	617,543	34,766	904,580	1,216,800
Miscellaneous*	254	306					
Total	20,082,703	20,064,152	20,745,644	20,046,905	1,495,371	47,306,204	48,182,833

*Includes Florida, Missouri, Tennessee, Utah, and Virginia.
[1]Includes Utah. [2]Includes Tennessee. [3]Includes Missouri.
[4]*Oil & Gas Journal*, February 24, 1944.
[5]*Oil & Gas Journal*, January 27, 1944.
[6]*Oil & Gas Journal*, January 28, 1943.

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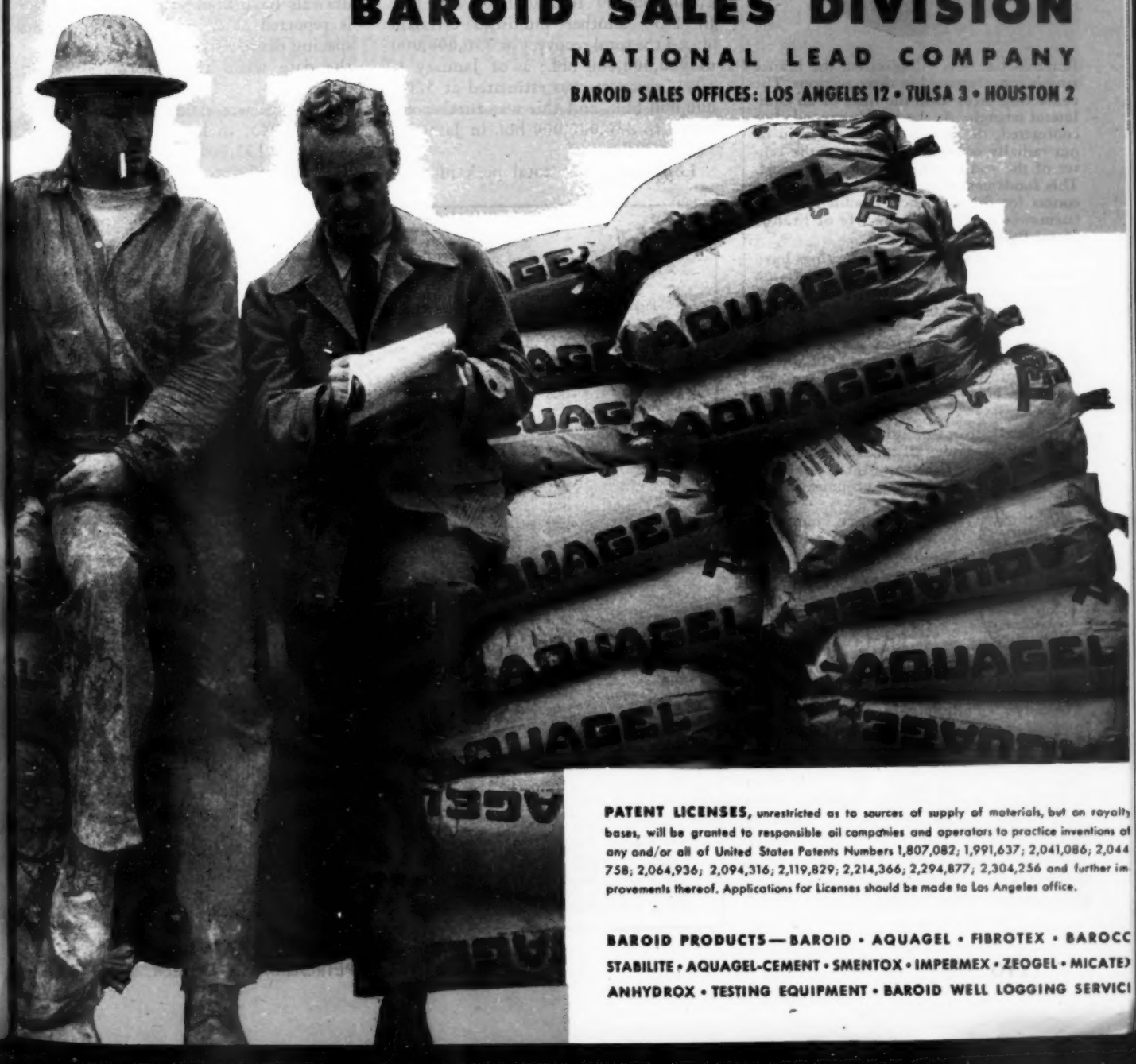

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recovery factor, the recovery would be 122,000,000 bbl., and with a factor of 60 per cent the recovery would be 146,640,000 bbl. Production practices in this field include 40-acre spacing and withdrawals are restricted; also porosity and permeability are not high, and under these various conditions the writer is of the opinion that a recovery factor of 40 per cent is not unreasonable.

The Rodessa field in Miller County, Arkansas, was discovered in 1927. An estimate of ultimate recovery made in 1938 was 27,600,000 bbl. This was revised to 9,600,000 bbl. in 1943, and to 8,000,000 bbl. in 1944. U. S. Bureau of Mines estimate for the Rodessa field in Miller County as of January 1, 1943, was 8,000,000 bbl. Spacing in this field averages about 15 acres per well, and withdrawals have been restricted.

California. With one exception, early published estimates of reserves in California are not available to the writer. In 1934, estimate of ultmate recovery of the Kettleman Hills field was 1,000,000,000 to 2,000,000,000 bbl. In 1939 another published estimate placed the total recovery at 750,000,000 to 900,000,000 bbl.; as of January 1, 1943, recovery was estimated at 570,000,000 bbl., and this was further reduced to 430,000,000 bbl. in January, 1944.

Louisiana. The total peak of estimated recoveries of the 13 fields in Louisiana enumerated in Table 3 amounts to 978,000,000 bbl. Revisions downward of these 13 fields as of January 1, 1944, show a total estimated recovery of 579,000,000 bbl., which amounts to a reduction of about 45 per cent from the peak estimates.

Rodessa field, Louisiana, was estimated in 1938 at 157,000,000 bbl. In 1944 this was reduced to 98,700,000 bbl. Spacing was on basis of 20 acres per well, and wells in the early life of the field were restricted in production.

The Lafitte field at the beginning of 1942 was estimated to have an ultimate recovery of 142,200,000 bbl. In 1944 this is reduced to 80,300,000 bbl. Spacing is on basis of about 40 acres per well, and withdrawals have been restricted.

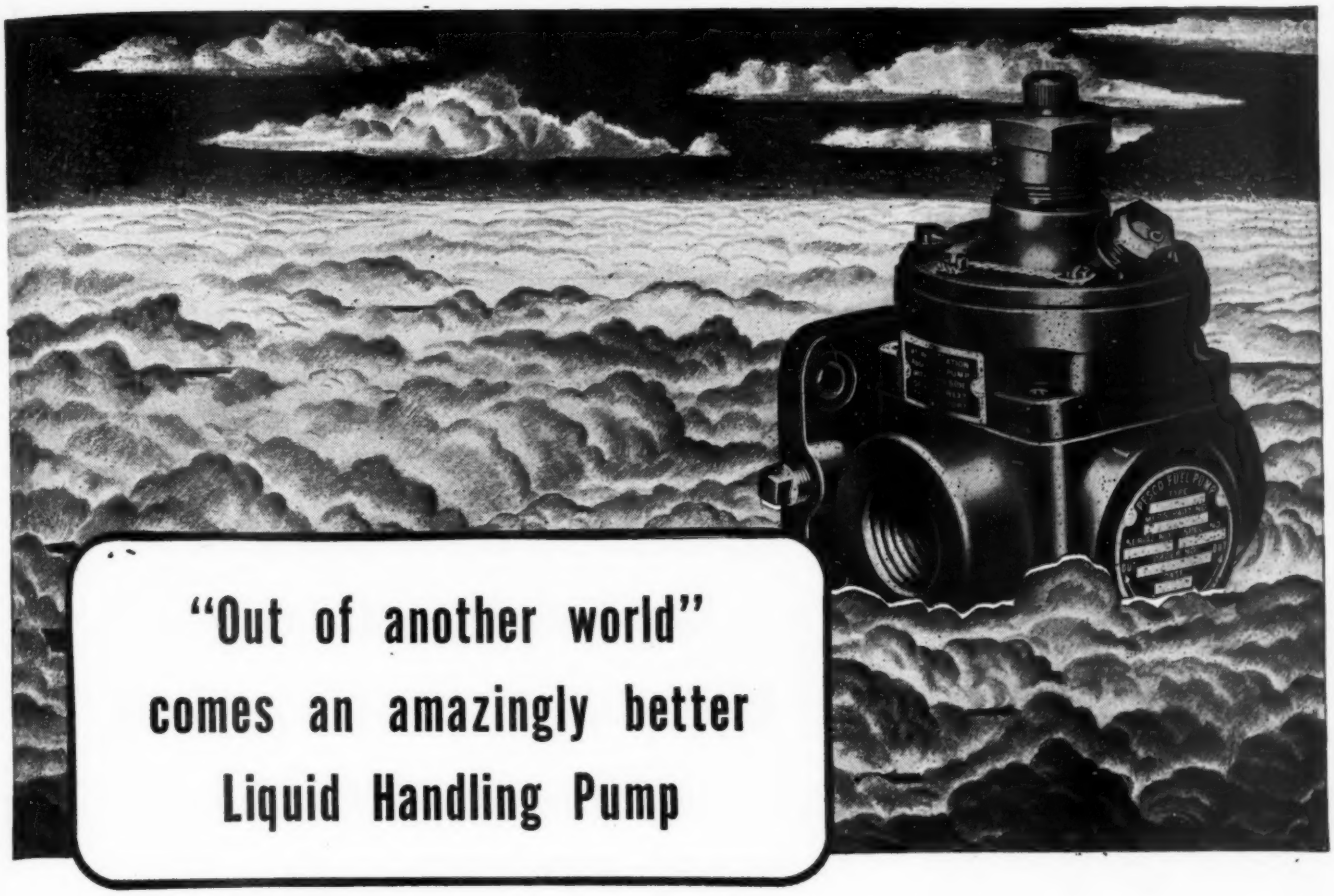
The Paradis field in July, 1940, was estimated to have an ultimate recovery of 140,000,000 bbl. In January, 1944, this estimate was reduced to 56,000,000 bbl. Spacing has been on basis of about 100 acres per well and withdrawals have been restricted. Porosity is reported as 25 per cent. Probably spacing density has been increased since the date when this information was noted.

Jennings was estimated as of January 1, 1943, to have an ultimate recovery of 135,000,000 bbl, but a year later this estimate was reduced to 115,-

TABLE 2
Estimated reserves of principal fields of the United States, in thousands of bbl.

Field	Year discovered	1937[1]	1938[2]	1939[3]	1940[4]	1942[5]	1943[6]	1944[7]	Remaining 1-1-1944[7]
East Texas	1930		3,250,000				4,500,000	4,500,000	2,520,100
Midway-Sunset	1901						1,150,000	1,160,800	197,300
Coalinga	1900						865,145	850,000	412,600
Long Beach	1921						780,000	790,000	98,300
Oklahoma City	1928						708,320	708,320	114,600
Conroe	1931		670,000	700,000	700,000	704,200	700,000	700,000	537,900
Yates	1926	675,000				668,100	672,900	671,700	386,800
Bradford	1871						665,000	665,000	204,300
Kettleman Hills	1928			750,000 900,000			570,000	430,500	149,900
Slaughter	1937					286,500	471,320	471,320	445,300
Hendrick-Kermit	1927	280,000				270,800	462,550	393,160	118,800
Wasson	1936					448,100	453,650	453,550	399,200
Van	1933		325,000			325,000	442,800	440,010	300,700
Huntington Beach	1920						435,000	440,000	113,100
Wilmington	1935						400,000	500,000	291,600
Tom O'Connor	1934	125,000		301,000		312,200	400,000	400,000	353,300
Ventura Avenue	1916						400,000	435,000	167,000
Eunice-Monument	1928	375,000				366,300	381,000	371,000	234,600
Goldsmith-Harper	1934	100,800				367,300	380,000	383,710	327,700
Hastings	1934		400,000	375,000	360,000	365,300	375,000	370,000	306,400
Webster	1937		250,000	350,000	410,000	414,000	350,000	350,000	325,900
Elk Hills	1919						335,000	385,000	217,500
Anahuac	1935		300,000	291,000	278,500	255,100	290,000	290,000	257,500
K. M. A.	1931						288,800	280,000	228,300
West Ranch	1938			32,400		185,300	240,000	238,000	220,000
McElroy	1926	115,200				249,500	236,000	226,000	93,000
Thompson	1931		210,000	225,000	246,500	263,400	225,000	225,000	176,100
Cowden-Foster	1930					283,400	214,500	214,500	160,600
Hawkins	1940						200,000	200,000	178,500
Louden	1937			165,000			195,400	195,500	94,000
Magnolia	1938					180,000	180,000	150,000	119,300
Penwell-Jordan	1930	31,500				36,800	166,510	166,510	129,200
South Ward	1930	57,600				44,100	145,170	145,070	94,200
Vacuum	1929					82,100	135,000	135,000	113,500
Seminole, Texas	1937					132,000	110,000	110,000	101,800
Total									10,188,700

[1] *Oil Weekly*, July 19, 1937.
[2] *Oil Weekly*, July 25, 1938.
[3] *Oil Weekly*, October 9, 1939.
[4] *Oil Weekly*, September 23, 1940.
[5] *Oil Weekly*, March 16, 1942.
[6] *Oil & Gas Journal*, January 28, 1943.
[7] *Oil & Gas Journal*, February 10, 1944.



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000,000 bbl. This field has had two periods of discovery, the latter one taking place in 1936 on the south flank, and a revision upward of the recovery estimate reached 130,000,000 bbl. as of July 1, 1940, which was later reduced to 115,000,000 bbl. Wider spacing and restricted production may have played a part in these later estimates.

The Ville Platte field was discovered in 1937 and on January 1, 1942, ultimate recovery was estimated at 92,700,000 bbl. On January 1, 1944, this was reduced to 69,000,000 bbl., a reduction of about 25 per cent. Production comes from the Sparta and Wilcox formations; porosity is estimated as 21 per cent. Spacing is on basis of one well to 20 acres, and production has been restricted. A certain amount of pressure maintenance has been in force, and an abundance of formation water has been produced in many of the wells from a time early in their history.

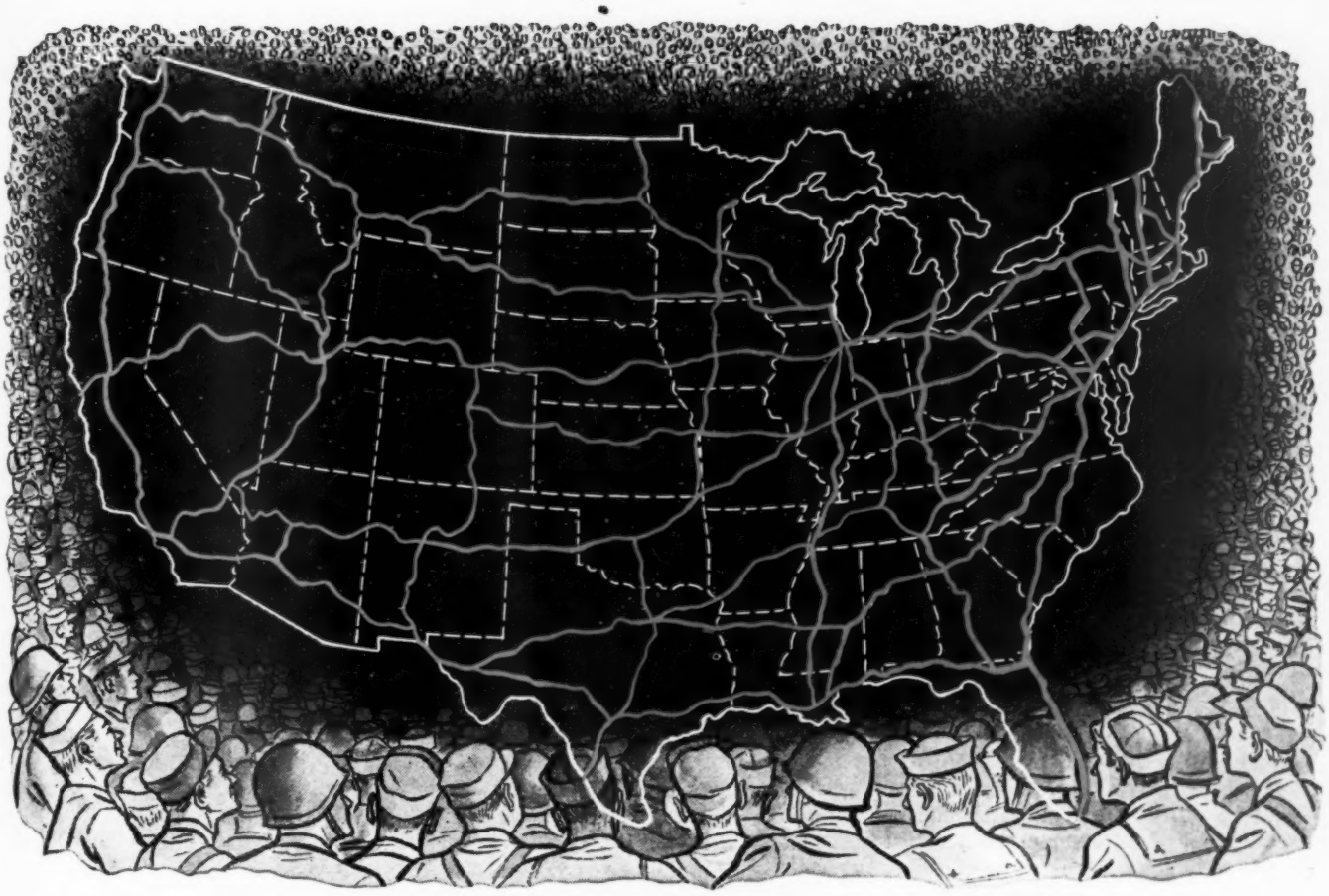
New Mexico. The Eunice field was discovered in 1928, but not until 1937 had estimates of recovery reached 200,000,000 bbl., which have since been trimmed to 160,000,000 bbl. There is much uncertainty in making recovery

TABLE 3

Estimated ultimate recovery in fields that have been revised downward, in thousands of bbl.

Field	Year discovered	1938	1939	1940[5]	1942[6]	1943[7]	1944[8]	Peak of estimates
Arkansas		[1]						
Magnolia	1938				180,000	180,100	150,000	180,000
McKamie	1940				37,500	37,500	17,500	37,500
Rodessa	1937	27,600			8,000	9,600	8,000	27,600
Total							175,500	245,100
California								
Kettleman Hills	1928		750,000[4] / 900,000			570,000	430,000	1,000,000[9] / 2,000,000
Louisiana		[1]						
Rodessa	1930	157,000			102,000	108,700	98,700	157,000
Lafitte	1935	100,000	70,000	126,350	142,200	80,200	80,300	142,200
Paradis	1939			27,000	100,800	56,000	56,000	140,000
Jennings	1901	90,000	106,275	100,275	101,560	135,000	115,000	135,000
Ville Platte	1937	15,000	37,130	54,500	92,740	78,000	69,000	92,740
Erath	1940				64,600	2,600	2,500	64,600
Eola	1939			54,000	57,500	60,000	40,000	75,000
Golden Meadow	1938		1,000	20,000	34,500	56,510	46,510	56,510
Bosco	1934	30,000	25,000	25,000	25,300	40,000	31,000	40,000
Charenton	1936	10,000	5,500	12,500	14,600	26,600	20,600	28,000
Bancroft	1938		5,740	16,600	8,400	9,600	5,000	20,000
Little Creek	1936					14,500	9,500	14,500
Creole	1938	2,000	12,500	12,500	2,930	9,600	5,600	12,500
Total							579,710	978,050
New Mexico		1937[3]						
Eunice	1928	200,000			160,220	170,000	160,000	170,000
Penrose	1935	25,000			26,600	21,500	14,500	26,600
Hardy-Skaggs	1935	3,800			17,360	15,200	9,200	17,360
Skelly	1936	8,000			11,760	9,500	6,500	11,760
Total							190,200	225,620
Gulf Coast		[2]						
Webster	1937	250,000	350,000	410,000	414,000	350,000	350,000	414,000
Anahuac	1935	300,000	291,000	278,500	255,000	290,000	290,000	300,000
Thompson	1931	210,000	224,980	246,000	263,400	225,000	225,000	263,400
Old Ocean	1934	100,000	31,420	161,850	162,700	46,500	53,500	162,700
Barbers Hill	1916	80,000	75,000	75,000	93,740	105,000	95,000	105,000
Lovells Lake	1938	8,000	20,030	35,430	36,500	58,000	48,100	58,000
Oyster Bayou	1941				45,040	2,300	10,200	45,040
Dickinson-Gillock	1934	40,000	44,750	44,750	40,470	45,000	36,000	45,000
Clear Lake	1938	1,000	33,785	25,600	24,130	34,000	28,000	34,000
Bay City (Van Vlk)	1934	20,000	24,000	30,000	28,160	23,000	11,000	35,000
Segno	1936	10,000	5,500	30,500	30,070	22,000	22,000	30,500
Joe's Lake	1937	5,000	15,000	25,000	29,480	18,000	8,000	30,000
Lochridge	1936	15,000	24,000	24,000	21,200	10,250	10,250	24,000
Seabreeze	1936	20,000	15,000	9,640	9,480	11,000	6,000	20,000
Minnie Bock	1939				2,580	14,000	10,000	14,000
Markham	1908	10,500	11,000	11,000	10,900	12,800	8,525	12,800
Louise	1933	5,500	6,530	6,530	6,420	8,000	8,000	10,000
Total Gulf Coast							1,230,715	1,614,580
West Texas								
Slaughter	1937				286,480	481,320	471,320	481,320
K. M. A.	1931					288,880	280,000	288,880
Kermit	1928	84,000			45,900	111,750	51,750	111,750
South Ward	1930	57,600			44,100	107,190	55,900	107,190
Keystone	1930	50,000			17,400	54,000	35,940	54,000
Iatan-Snyder	1926	43,200			37,960	49,360	39,350	49,360
Wheat	1925				12,000	18,000	13,000	18,000
Cowden-Crane	1926				6,600	10,000	6,500	10,000
Total							953,760	1,120,500

[1] *Oil Weekly*, March 28, 1938.
[2] *Oil Weekly*, July 25, 1938.
[3] *Oil Weekly*, July 19, 1937.
[4] *Oil & Gas Journal*, February 9, 1939.
[5] *Oil Weekly*, September 23, 1940.
[6] *Oil Weekly*, March 16, 1942.
[7] *Oil & Gas Journal*, Januray 28, 1943.
[8] *Oil & Gas Journal*, January 27, 1944.
[9] *Oil Weekly*, August 27, 1934 .



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estimates in limestone fields, and it remains to be seen whether the downward revision in this field has reached the lowest limit.

The Penrose field, carried at 26,600,000 bbl. in 1942, is reduced to 14,500,000 bbl. in 1944, and the Hardy-Skaggs field, placed at recovery of 17,400,000 bbl. in 1942, is reduced to 9,200,000 bbl. in 1944, and the Skelly field, carried at 11,700,000 bbl. in 1942, becomes 6,500,000 bbl. in 1944.

Texas. Much the largest of all known oil fields in the world is the East Texas field where the published estimated recovery is now 4,500,000,000 bbl., of which less than 50 per cent has been produced. One large company with extensive interests in this field has placed a figure of 4,200,000,000 bbl. on this field, which is a reduction of 300,000,000 bbl. from the published estimate. Only time will reveal the accuracy of these guesses, however intelligently they may have been made.

The Webster field, discovered in 1937, was given an ultimate recovery estimate of 414,000,000 bbl. in July, 1940; in January, 1944, this was reduced to 350,000,000 bbl., which is a reduction of 64,000,000 bbl., and because only about 10 per cent of this quantity has been extracted it is impossible now to predict what will happen to these estimates in the course of the next 5 to 10 years, even if production be on a much higher basis of withdrawal. Spacing is on basis of 20 acres per well, and withdrawals have been greatly restricted.

The Anahuac field was given an ultimate recovery guess of 300,000,000 bbl. in 1938. This is reduced to 290,000,000 bbl. in 1944, although another estimate in 1940 placed ultimate recovery at 255,000,000 bbl. Data given in U. S. Bureau of Mines Report of Investigations 3579 would imply that a lower recovery than 255,000,000 bbl. can be expected. Spacing is on basis of 20 acres per well, and withdrawals have been greatly restricted.

The Old Ocean field was estimated in January, 1942, to have an ultimate recovery of 162,700,000 bbl. This was reduced in January, 1944, to 53,600,000 bbl. Spacing is on basis of 40 acres per well, porosity is reported at 27 per cent, and withdrawals have been restricted.

It will be noted that all Texas Gulf Coast fields listed in Table 3 with two exceptions were discovered and developed since 1930, when wide spacing and restricted production came into use.

West Texas fields. Seven fields, or areas, are included in West Texas fields where recovery estimates have been revised downward. The peak estimates reach a total of 1,120,000,000 bbl. The question in the writer's mind is the extent of revision that will take place in these fields after they reach a recovery of 50 per cent or more of the peak estimates. Some of these fields have been developed on basis of 20 to 40 acres per well, and withdrawals have been low; therefore, evidences of the effect of these producing practices do not become evident until a number of years have passed.

In Table 2 various fields such as East Texas, Conroe, Yates, Wasson, and Slaughter, are carried at very high ultimate recovery estimates, and have not yet been revised downward. Spacing, completion practices, and daily withdrawals have been very different from practices followed in fields developed prior to 1930, and it remains to be seen whether the estimates of these fields will have to be revised downward.

Heard at the A.P.I. Meeting

The oil industry spends $18,000,000 *to* $21,000,000 *a year to prepare reports to federal agencies on material purchases alone. What is true of the oil industry must to a large extent be true with all other industries, all going to show that the results of bureaucratic control at Washington are very expensive to the American people, who pay the bills for the war effort.*

—J. Edgar Pew, vice president, Sun Oil Company.

If the present upswing in drilling activity is continued, the industry must receive an improved quality of materials; adequate stocks of repair parts; improved service facilities, and relief from shortage of manpower.

—W. H. Morrison, Shell Oil Company.

In many instances the oil recovered through secondary recovery from individual properties has considerably exceeded the primary recovery. Also, where it has taken 25 to 50 years to produce a given quantity of oil by primary operations, with operating and other expenses continuing over an equal length of time. Water flooding of the property has recovered the same volume of oil in from 3 to 5 years.

—Charles B. McClintock, Secondary Recovery Unit, PAW

In a previous article* the writer compiled data on fields along the Gulf Coast that were developed prior to 1930, also on fields that were developed since that year. These fields are summarized in Table 4.

Spacing in Louisiana Gulf Coast wells developed prior to 1930 averaged 2.6 acres per well, and has averaged about 21 acres per well since 1930. In Texas Gulf Coast fields prior to 1930 the spacing averaged 1.4 acres per well, and since 1930 it has averaged about 17.5 acres per well.

Reference was made in the first paragraph of this article to the price of oil, which in the opinion of the writer is the dominating influence that in the long run governs all production practices. During the previous World War the price of oil was about $3.00 per bbl.; wells in few cases had reached 4000 ft. in depth; labor cost was much lower than at present; materials were much lower in price, and taxes were very much lower. During the present war, the labor cost is about double that in 1918; materials are much higher; taxes are several times as great; wells will average about twice the depth of those in 1918, and the price of oil is about one-half that which prevailed in 1918. It should cause no wonder, therefore, that wells are being spaced much farther apart; that casings are smaller rather than larger for wells of twice the depth; that completion practices do not make for the highest ultimate recoveries, and that many wells are being abandoned prematurely because the price of oil does not justify the lifting of oil containing large percentages of water from these greater depths.

TABLE 4

Data on fields along the Gulf Coast developed before and after 1930

State	When developed	Number of fields	Total number wells drilled	Productive acres	Estimate ultimate recovery		Production to end of 1940	
					Thousand bbl.	Bbl. per acre	Thousand bbl.	Bbl. per acre
Louisiana	Before 1930	11	1,905	5,010	373,800	74,800	262,700	52,400
Louisiana	After 1930	29	1,893	39,410	1,038,300	26,300	298,500	7,600
Texas	Before 1930	19	10,163	14,140	1,115,400	78,900	905,600	64,000
Texas	After 1930	22	5,163	98,220	2,601,200	26,500	353,980	3,600

*"Recoveries Obtained Under Different Extraction Methods in Various Fields," S. F. Shaw, *Oil Weekly*, December 7, 1942.

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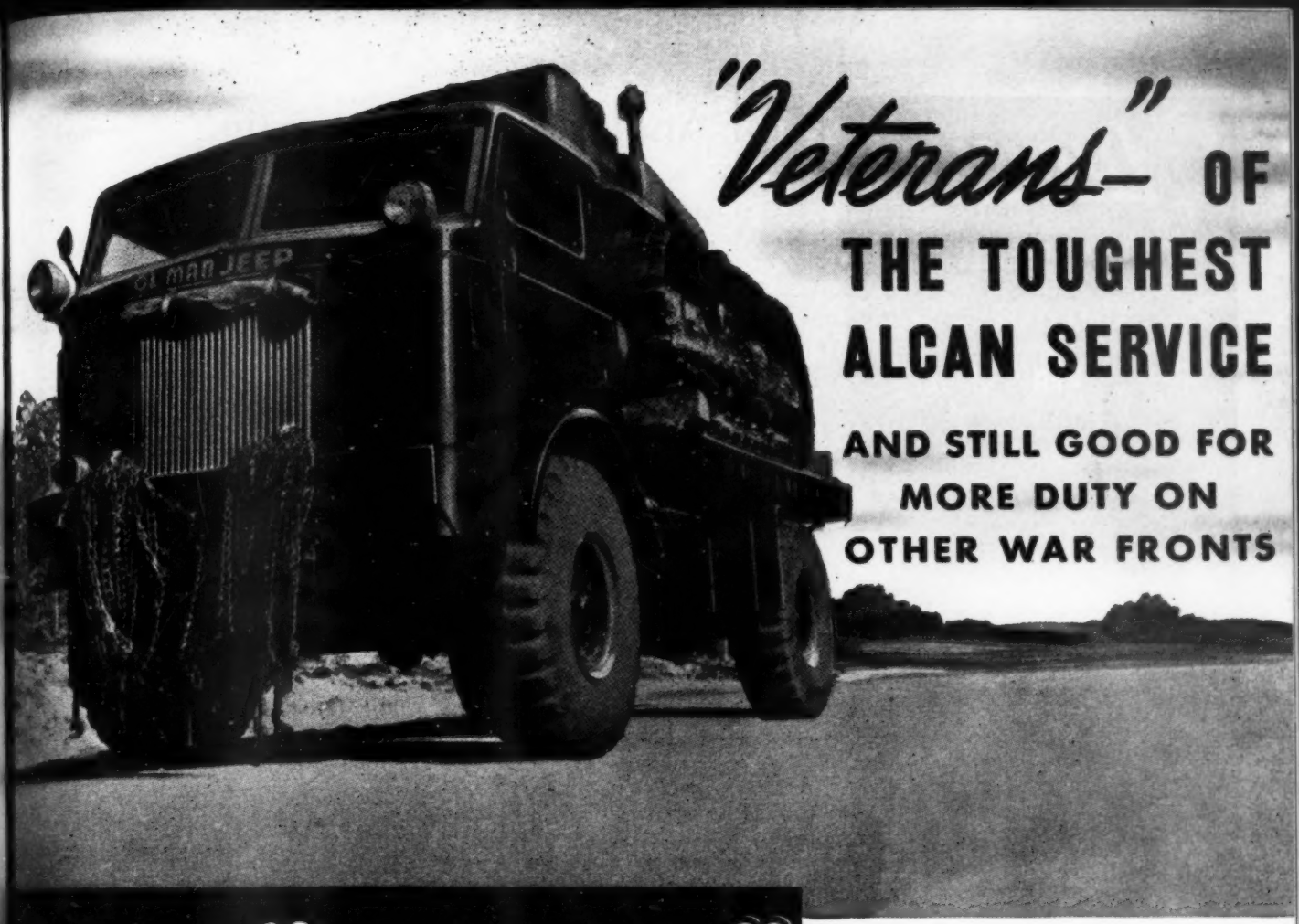

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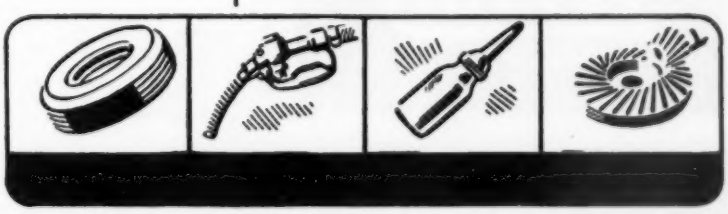

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Soil Analysis for Prospecting

by Homer I. Henderson

Universal Oil Tool Company

THE soil analysis method developed by the Surface Analysis Company is a process of analyzing the surface soil for accumulation of hydrocarbons. From a subterranean reservoir of oil the molecules of gaseous hydrocarbons are continually diffusing to the surface. This process is exceedingly slow. Furthermore, a very large part of the molecules, upon reaching the surface, escape into the atmosphere unchanged. Fortunately some of the molecules, certain unsaturated ones especially, are transformed upon reaching the surface. This transformation is one of oxidation or dehydrogenation, brought about by intimate contact with air under the influence of sunlight and in the presence of certain catalysts, some of which are nearly always present in surface soils. In some cases this transformation appears to be a combination of oxidation, polymerization, and photo-synthesis.

With certain oils at shallow depths, and with unconsolidated over-burden, this process results in a considerable accumulation of the transformed hydrocarbons; for instance, the paraffin earth over the shallow Gulf Coast salt domes. This accumulation has occurred throughout the centuries. An accumulation with a concentration of only a fraction of 1 per cent of the concentration in paraffin earth can be detected in the laboratory by the process developed by this company, but it must be understood that it is a case of measuring the accumulation of transformed hydrocarbons rather than capturing and measuring the few molecules that might be in process of diffusing at the time the sample was taken. Such diffusing molecules, especially methane, may be generated near the surface by decaying vegetable matter, hence it is apparent that any successful process must differentiate between surface generated hydrocarbons and hydrocarbons from deeply buried mineral oils.

For an area to be worked satisfactorily by this method, the surface conditions must be favorable for accumulation of the transformed hydrocarbons. If the surface is covered with water the transformation products are carried away as fast as formed, if in fact they are formed at all in the absence of catalysts. This condition is indicated in the accompanying drawing by zone "C." Obviously, it is hopeless to employ surface analysis under such conditions.

If, on the other hand, the surface is considerably above sea level, such as zone "A" in the figure, the transformation products are absorbed by the soil particles as they are formed. A subsequent inundation of the surface will not leach them out. This makes for a favorable condition, even though the inundations are relatively frequent.

The surface condition as represented by zone "B" is an intermediate condition wherein the surface is inundated with every high tide; however, during low tide the surface is exposed and a condition partly favorable for accumulation exists. Nevertheless, such an area cannot be considered as a favorable area at the present time.

There exists in the Gulf Coast a condition whereby a strong south wind will cause an excessively high tide, which will inundate large areas that are normally above water. Such areas that get only an occasional inundation can be worked satisfactorily.

Another question that should be given prime consideration is: Is the marsh land rising or subsiding? In some areas of the Gulf Coast, notably the Mississippi Delta, the land mass is subsiding at a relatively rapid rate and large areas are becoming marsh and swamp that once were relatively high land. Such areas throughout the past ages have been favorable for surface accumulation and are now workable by soil analysis. The alternative condition, where the land is rising, a new surface is being exposed, a surface that has not had time for surface accumulation and is not a favorable area for surface analysis. A similar condition exists when a new surface is continually being added by alluvium deposits, or humus accretions. These of course result in a surface that is decidedly not favorable for accumulation.

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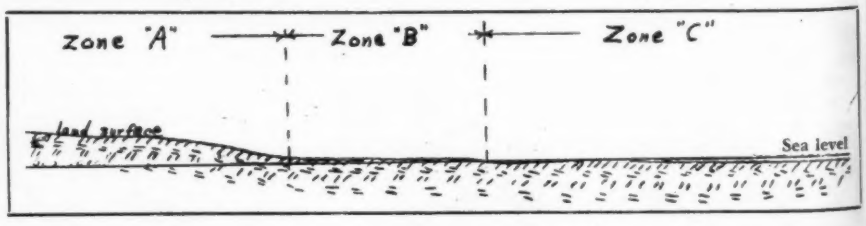

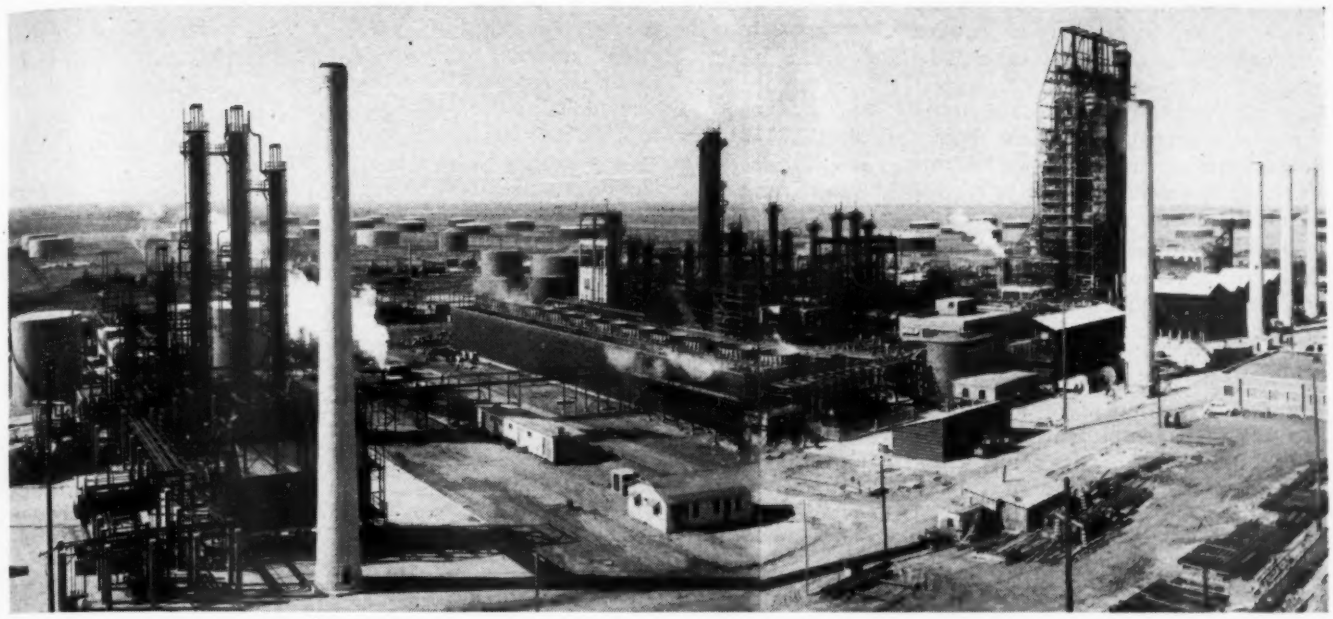

Continental Oil Company's 100-octane aviation gasoline plant (center and right). At left is company's toluene plant

Continental's 100-Octane Plant Is Placed on Stream

Oklahoma plant is first in state to manufacture finished product

CONTINENTAL OIL COMPANY on May 25 at Ponca City manufactured the first barrel of 100-octane aviation gasoline ever to be completely made in a single plant in Oklahoma.

The announcement came from Dr. Walter Miller, vice president in charge of manufacturing, with the beginning of complete operation of Continental's new 100-octane plant, a Defense Plant Corporation project, costing approximately $17,000,000.

"Although Continental and several other Oklahoma refineries have been making ingredients for 100-octane gasoline for some years," said Dr. Miller, "This new plant is the first in the state to manufacture the finished product. We are not permitted under censorship regulations to reveal the plant's capacity, but our first blend today yielded more than 25,000 bbl., all of which will go directly to our armed forces."

Construction work on the plant was started early in August, 1942. It was built under contract with the Lummus Company, New York. As many as 1600 men have been employed in construction work. The operation crew will total about 250 men.

The 100-octane plant includes two thermofor catalytic cracking units, a thermofor catalytic cracking retreating unit, a hydrofluoric acid alkylation unit, and an aluminum chloride isomeration process in addition to the main processes. It has a control laboratory, rail trackage for simultaneous loading of 30 tank cars, storage for 240,000 bbl. of finished products, and a redwood cooling tower for cooling 30,000 gallons of water per minute.

Central unit in the plant is a T.C.C. tower that reaches 234 ft. above the surrounding terrain. There are four stacks 125 ft. high, and one stack 150 ft. high. The isopentane tower, which weighs 118 tons, is 11 ft. in diam. and 132 ft. high. It was shipped to Ponca City in one piece on three railroad flat cars.

Self-Contained Project

Continental's 100-octane plant is a completely self-contained project for the production of blended aviation gasoline of such specifications as may be required to meet army and navy needs. The various components entering into the final blend of 100-octane aviation gasoline will be manufactured in the new facilities from raw feed stocks available from the refinery. Such feed stocks will consist primarily of gas oil produced from refinery topping operations, a quantity of blending components fractionated and extracted from hydroformate available in the refinery and from butane-butylenes from the refinery thermal cracking and topping operations.

Existing facilities in Continental's Ponca City refinery will be used for the production of the raw feed stock and the reprocessing of cycle and by-product stocks from the new aviation gasoline facilities, thus permitting Continental to produce the maximum possible quality of 100-octane aviation gasoline to meet the national defense needs.

T.C.C. Unit Operation

The two thermofor catalytic cracking units will be operated on a 1 to 1

recycle cracking operation on gas oil. The wet gas and distillate or gasoline produced from this operation will be pumped and compressed to high pressure for further processing through a feed preparation unit. Various specification cuts of distillate may be produced as by-products from the catalytic cracking units.

The debutanized distillate or gasoline from the cracking operation is then reprocessed through the catalytic retreating unit for the production of specification aviation gasoline base stock. The gasoline and wet gas produced from the retreating unit, which are produced at substantially atmospheric pressure, must be pumped and compressed to high pressure for further processing through a separate feed preparation unit from that used to stabilize and recover gasoline from the cracking operation.

In the combined feed preparation unit, the gasoline produced is completely debutanized; and the wet gases are substantially completely stripped of all butane components. This butane-butylene mixture is thus recovered for further processing through the alkylation and isomerization units after combining with butane-butylenes recovered from the main refinery operations or purchased from outside sources.

Alkylation Unit

The butane-butylenes available are processed through a hydrofluoric acid alkylation unit operated in conjunction with an aluminum chloride isomerization plant for the production of aviation alkylate. The isomerization unit is operated to convert normal butane into isobutane, an essential component for the production of alkylate or isooctane. Isobutane in the presence of hydrofluoric acid as a catalyst is joined together with butylenes or may be joined with propylenes or amylenes for the production of aviation gasoline blending components known as alkylate. While this plant is primarily designed for the production of alkylate from butylenes, any available capacity of the plant will be utilized in alkylation of propylenes and amylenes for the production of the maximum quantity of alkylate.

As previously stated, by-products from the combined aviation gasoline plant operations will be returned to the main refinery for disposal or for further processing through thermal cracking equipment, thus producing additional butane-butylenes to increase the output of ultimate aviation gasoline.

Since sulphur compounds are extremely detrimental to the quality of aviation gasoline, all butane-butylenes entering the alkylation and isomerization units are previously passed through a two-stage caustic treating system for the removal of hydrogen sulphide and mercaptan sulphurs, thence through a clay drying system to remove the last traces of water present in this stock before being contacted with the acids used for catalyst in the alkylation and isomerization units.

The majority of the steam required for reboilers and prime movers in this plant is generated at 450 lb. Three 75,000-lb. per hr. high pressure boilers are augmented with high pressure steam produced from the thermofor catalytic cracking units. A part of this high pressure steam is utilized at the higher temperature level for reboiler services and the remainder of the requirement is expanded through turbines to 150 and 25-lb. systems for smaller pumping units and for lower temperature level reboiler requirements.

The cooling water required for the operation of this plant is maintained from a 30,000-gal. per min. induced-draft cooling-tower system.

Blending

The two basic aviation gasoline components, alkylate and thermofor catalytic retreated base stock, are then brought together in blending tanks equipped with agitators in the proper proportions to meet aviation gasoline specifications. Isopentane, another blending component for control of vapor pressure, may be produced from the operations as a separate component or left in the base gasoline, as desired. To this blend of components tetraethyl lead is added for maximum octane value.

The above two basic components may be augmented, and facilities are available in this new plant for increasing the volume by the use of CS blending components, additional lower grade marginal base gasoline (generally extracted direct from crude or fractionated as components of available refinery hydroformate), and various aromatic compounds including toluene for increasing rich mixture octane and performance value.

Facilities of this plant have been so arranged that a large quantity of the daily production may be rapidly moved by tank truck or the entire plant output moved by tank car to meet the demands and needs of the army and navy for this valuable war material.

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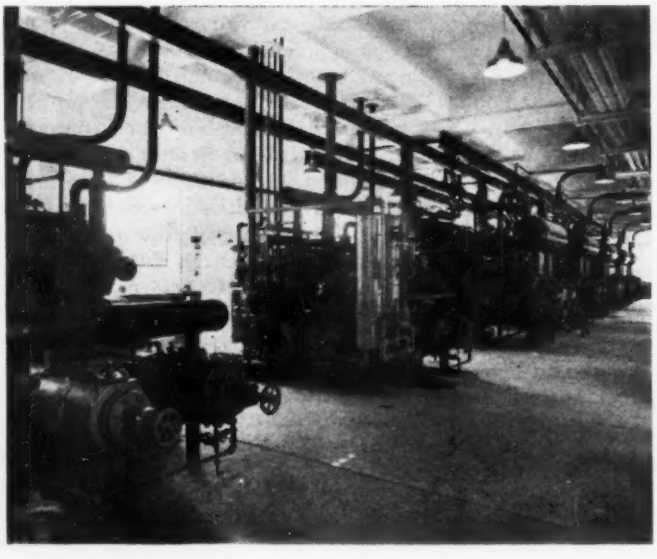
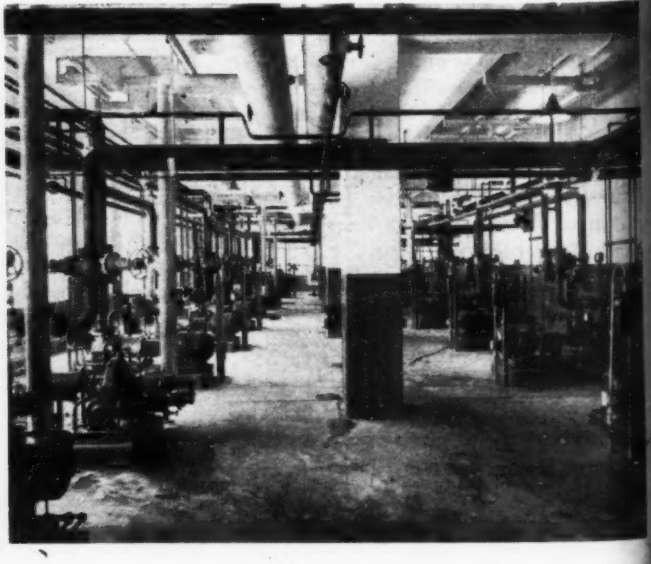
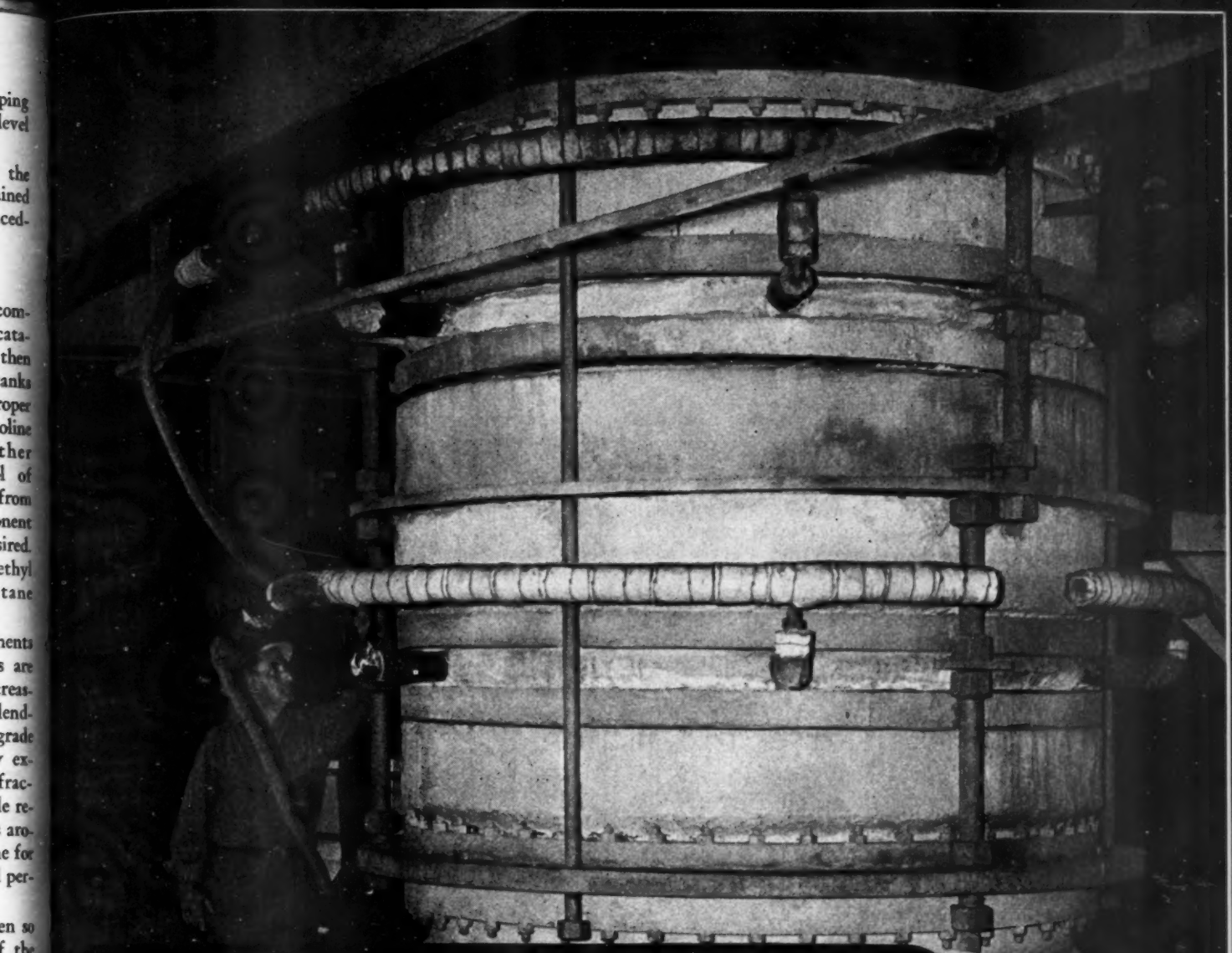
Compressors serving T.C.C. cracking and retreating units



Pump room for the T.C.C. feed preparation unit





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The Combustion Gas Turbine

PART 2 (Concluded)

by F. K. Fischer, Steam Engineer

and

C. A. Meyer, Development Engineer,

Westinghouse Electric and Manufacturing Company

THE third method of improving efficiency, reheating, consists of adding heat to the gas as it passes through the turbine as shown in Fig. 6. The gas turbine reheat cycle is the same principle as the reheat cycle used in many steam plants. In practice it will bear little resemblance. Reheating in the gas turbine will consist of burning fuel directly in the gas (approximately 85 per cent air) passing through the turbine. The quantity of large steam piping and considerable heat transfer surface in the heat exchanger of the steam reheat cycle will be replaced by a reheating combustor that may be placed inside the gas turbine casing proper. Here again, the practical number of reheats is limited. One reheat is illustrated in Fig. 6.

Reheating and intercooling increase the amount of useful energy per pound of working gas passing through the system, thus reducing the number of pounds of working medium circulated. Therefore, the size of piping and blade path in the compressor and turbine are reduced. In combination with a regenerator, the terminal difference across the heat exchanger is greater for a given size exchanger, or a smaller heat exchanger transfers the original amount of heat. In partial load operation they increase the partial load efficiency by a considerable amount.

Cycle Combinations Compared

The combination of regenerating, reheating, and intercooling is shown in Fig. 7. Different cycle arrangements are compared in Table I on the basis of the power requirements of each major element, with the capacity of the generator as unity. The efficiency of each cycle arrangement at 1200°F. is given, the temperature in degress Fahrenheit, and the absolute pressure at different points in each cycle.

The thermal efficiency of the open cycle gas turbine for various combinations of regenerating, reheating, and intercooling is shown in Fig. 8. This gives the relative value of these modifications and a general idea of possible applications of this cycle. The temperature range of 1000°F. to 1500°F. was chosen because applications at temperatures much below 1000°F. will undoubtedly be unpractical. Early applications for heavy duty long life apparatus will probably not exceed temperatures of 1200°F. with 1500°F. and higher limits awaiting future developments in metallurgy.

The temperature of the inlet air to the compressor has a marked effect on the cycle efficiency. In contrast to steam plants the colder this inlet air the higher the cycle efficiency and capacity. In the simple open cycle, changing the inlet air temperature 10°F. changes the cycle efficiency of 0.74 points or approximately 3 per cent for 10°F. change. The effect on capacity is approximately 4 per cent per 10°F. change. The effect on cycle thermal efficiency of inlet air temperature on the different cycle arrangements with a top temperature of 1200°F. is plotted in Fig. 9.

Steam and Gas Cycles Compared

Because steam is the most widely used medium for transferring heat into mechanical energy, a comparison of the steam cycle and the gas cycle may help in judging the gas cycle and its possibilities. In judging the efficiency of power cycles, a 100 per cent thermal efficiency is not obtainable as the temperature of the cold body is far above the absolute zero of temperature. The Carnot Cycle is theoretically a perfect cycle, and no cycle operating between the same hot and cold body temperatures can have a better thermal efficiency. The best any cycle can hope to do, when operating under the same conditions, is to attain the Carnot Cycle efficiency. The gas turbine cycle can theoretically give the same efficiency as the Carnot Cycle. This is only theoretically possible because it requires 100 per cent efficiency of the gas turbine and compressor, an infinite number of stages of intercooling and reheating and a regenerator infinite in size.

The steam cycle theoretically offers the Carnot Cycle efficiency only up to the critical pressure (705.4°F., 3206 lb. per sq. in. abs.). Above this temperature, the gap between the steam cycle and the ideal cycle gradually widens as the temperature is increased. From a purely theoretical standpoint the com-

Fig. 6. Reheat and regeneration for open cycle

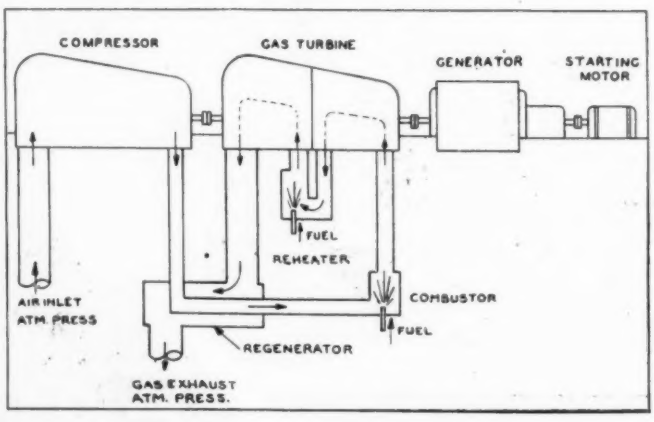
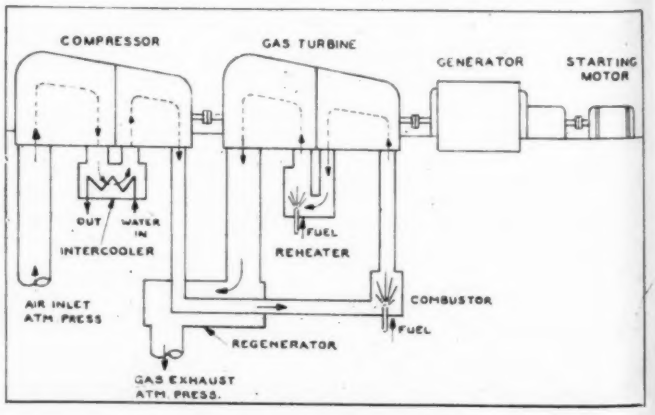


Fig. 7. Intercool, reheat, and regeneration for open cycle



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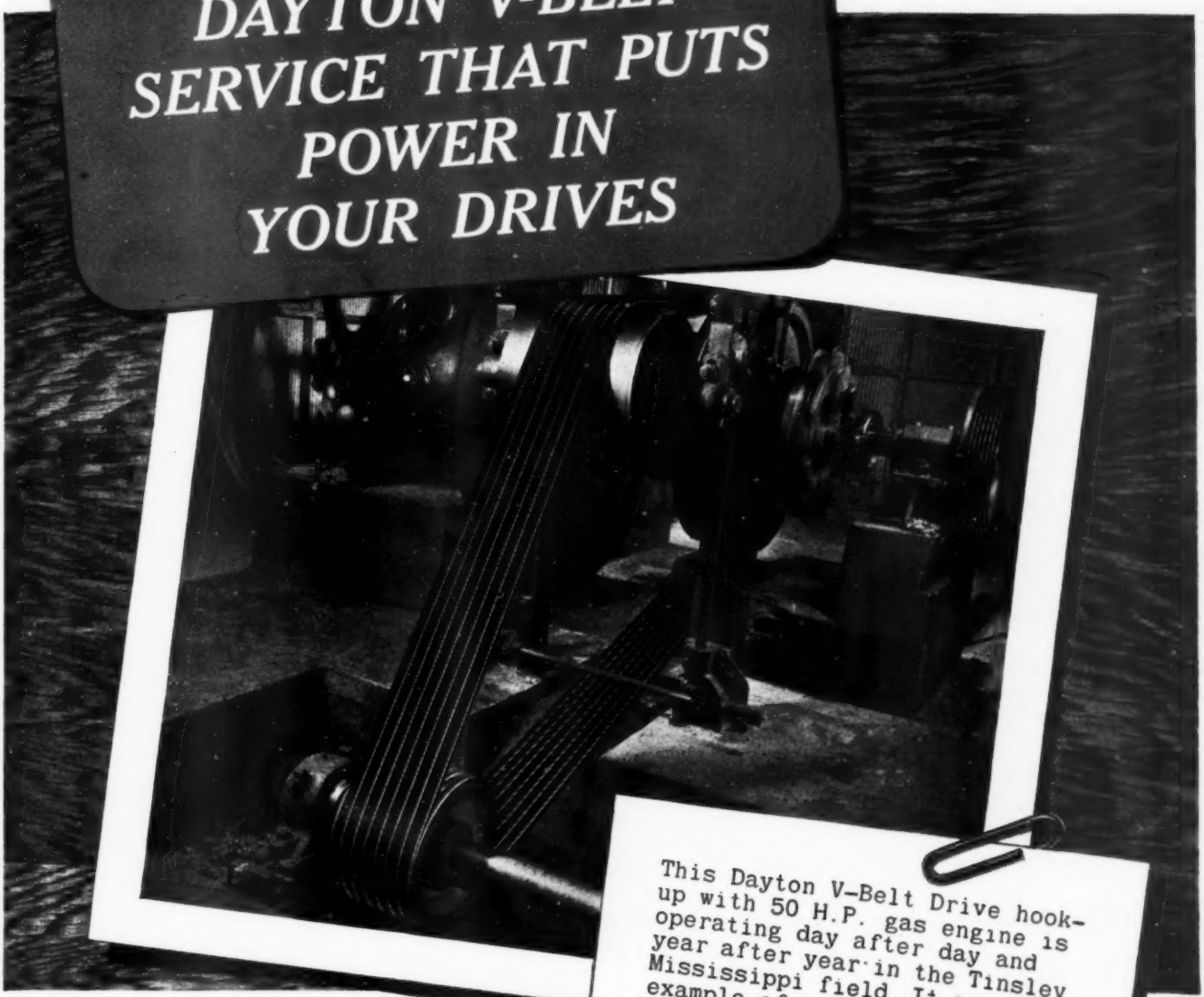

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bustion gas turbine cycle holds forth greater promise of efficiency than the steam cycle.

Gas Cycle Holds Promise

Of more value are the thermal efficiencies obtainable in practical applications. Fig. 10 compares the best efficiencies obtained in large central station power plants (projected to 2000°F.) with the expected practical limit in efficiency of the large capacity closed-cycle combustion gas-turbine power plants. Above 1000°F. the gas cycle efficiency increases approximately 3 times as fast as the steam cycle efficiency for a given top temperature increase.

This curve compares the best modern large central-station steam-power plants with the best practical efficiencies expected of the combustion gas turbine power plants. It is expected that the gas turbine cycle efficiency will not be greatly affected by unit size, and this combustion gas cycle curve can also be interpreted as applying to open cycle gas turbine power plants of relatively small capacity. Economic steam plants for capacities of about 5000 kw. seldom exceed 25 per cent overall thermal efficency. This would indicate a considerable efficiency advantage in small units in favor of the gas cycle, provided economics permit designing it for anywhere near its maximum possible efficiency.

TABLE I

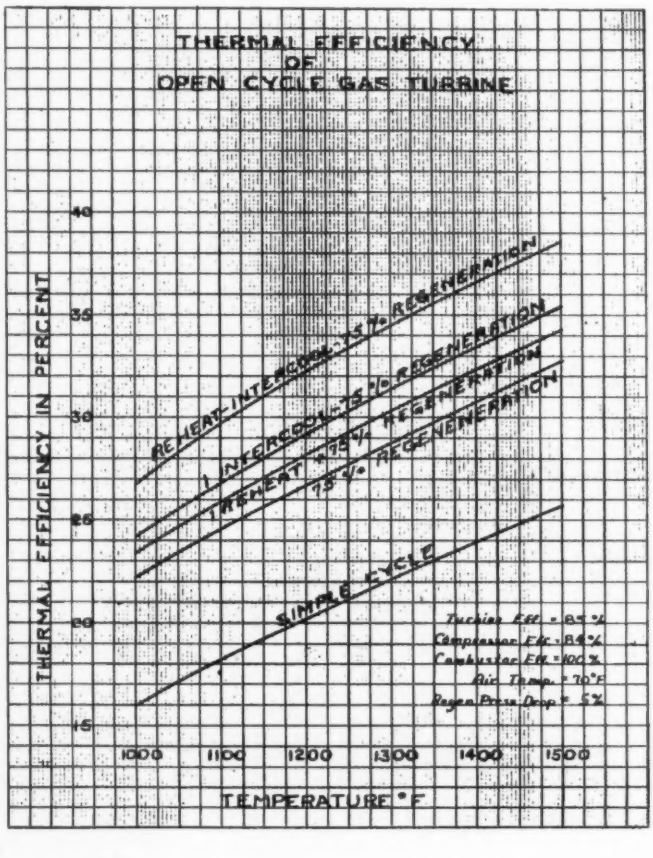
Effect of different open cycle arrangements on each major element

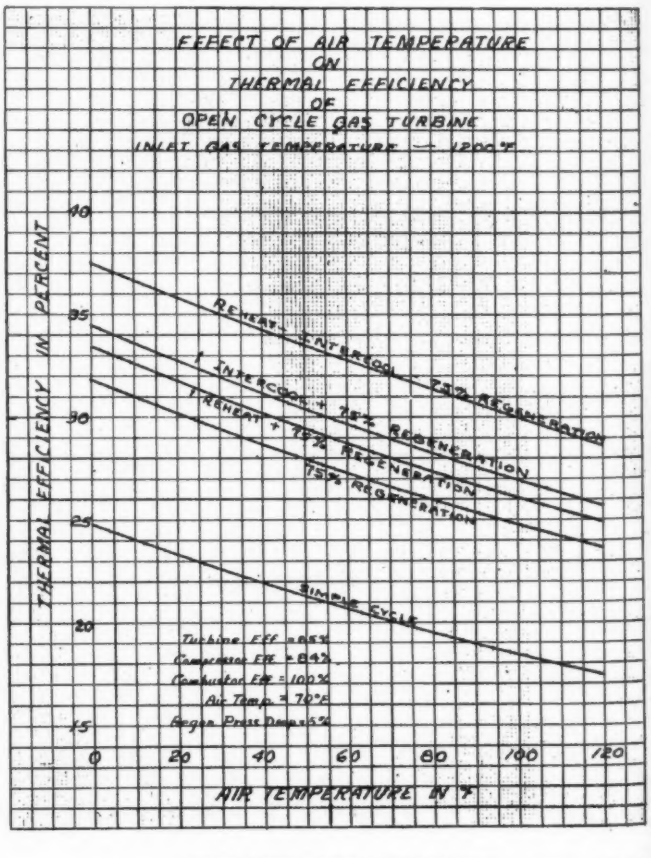
Item	Simple cycle	Cycle with regeneration	Intercool and regenerate	Reheat and regenerate	Intercool reheat regenerate
Figure No.	2	4	5	6	7
Input in fuel	4.95	3.75	3.43	3.55	3.11
Turbine rating	3.95	2.95	2.80	2.88	2.55
Compressor power	2.95	1.95	1.80	1.88	1.55
Useful output	1.00	1.00	1.00	1.00	1.00
Per cent efficiency at 1200°F	20.2	26.6	29.2	28.1	32.2
Gas temperature in °F. at					
Turbine inlet	1200	1200	1200	1200	1200
Leaving reheater	....	....	....	1200	1200
Turbine exhaust	635	790	695	920	865
Leaving regenerator	....	455	350	560	520
Air temperature in °F. at					
Compressor inlet	70	70	70	70	70
Leaving intercooler	....	....	70	....	....
Leaving compressor	490	340	230	440	405
Entering combustor	490	680	575	800	750
Pressure, lb. per sq. in. abs. at					
Compressor inlet	14.7	14.7	14.7	14.7	14.7
Compressor discharge	88.2	51.5	73.5	73.5	102.9
Turbine inlet	88.2	50.2	71.7	71.7	100.4
Turbine exhaust	14.7	15.1	15.1	15.1	15.1

A 3600-r.p.m. 5000-kw. steam turbine is compared with a 3600-r.p.m., 5000-kw. net-output open-cycle gas turbine in Table 2. The first column compares the simple cycle without reheat, intercool, or regeneration. Columns 2 and 3 make the comparison for a 5000-kw. net-output gas-turbine cycle using 1 intercool, 1 reheat, and regeneration. Column 4 compares a 5000-kw. steam turbine. This comparison indicates the low pressure in the open cycle gas turbine as compared with the steam cycle. As a result, the energy per pound of gas is small and the flow of gas is very large; 510,000 lb. per hr. for the simple-cycle gas turbine as compared to 52,500 lb. per hr. of steam to the steam turbine. The large flow and low pressure to the inlet of the gas turbine gives a large volume flow showing that the piping and blading of the gas turbine inlet are large compared to the steam turbine.

The ratio of exhaust to inlet volume is small for the gas turbine. This makes

Fig. 8 (left). Effect of reheat, intercool, and regeneration on thermal efficiency over range 1000 to 1500° F., based on 70° F. and 5 per cent pressure drop in regenerator. Assumed efficiencies: Turbine 85 per cent; compressor 84 per cent; combustor 100 per cent. Fig. 9 (right). Effect air temperature on thermal efficiency of open cycle gas turbine with 1200° F. inlet gas temperature. Efficiencies and regenerator pressure drop same as in Fig. 8





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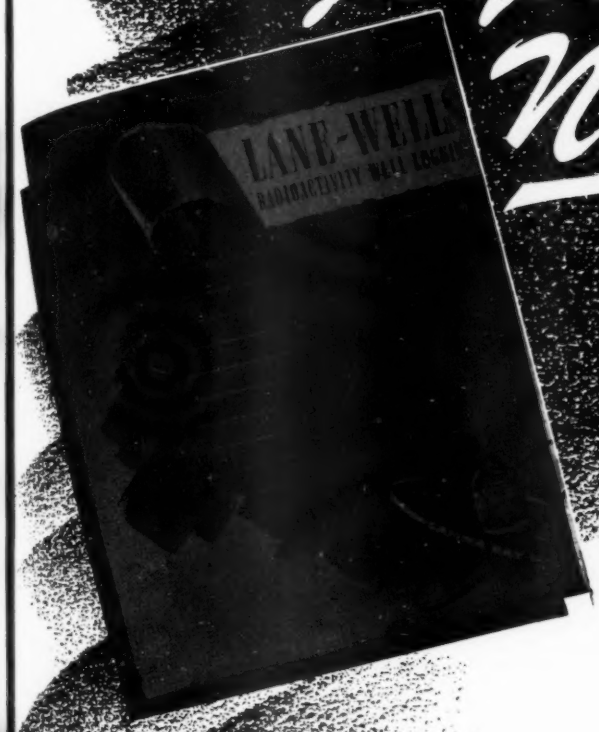

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TABLE 2

Comparison of combustion gas turbine and steam turbine

5000-kw. rating—3600 r.p.m.

Item	Open cycle gas turbine			Steam turbine
Cycle →	Simple cycle	One reheat, one intercool and regeneration		3 stages F. W. H.
	Single cylinder	H.P. turbine	L.P. turbine	Single cylinder
Inlet pressure, lb. per sq. in. abs.	88.2	100.4	39.4	465
Inlet temperature, °F. T.T.	1200	1200	1200	825
Exhaust Pressure, lb. per sq. in. abs.	14.7	39.4	15.1	3/4
Steam or gas rate, lb. per kw-hr.	102	56		10.5
Full load flow, lb. per hr.	510,000	280,000		52,500
Inlet vol. flow, cu. ft. per sec.	990	475		24.8
Exhaust vol. flow, cu. ft. per sec.	3900		3250	6120
Ratio (exhaust vol.÷inlet vol.)	3.95	6.85		250
Turbine floor area, sq. ft.	160	150	155	100 (turbine room only)
Net generator output, kw.	5000	5000		5000
Approximate plant thermal eff., %.	18.4*	29.4*		23.6

*Inlet air temperature, 70°F.

a balanced blade path unlike that of the steam turbine, which in this case must handle an exhaust volume 250 times as great as the inlet volume. The large blade dimensions limits the maximum net output rating of the open-cycle single-flow combustion gas turbine to approximately 7500 kw. Injection of liquids, however, presents a theoretical possibility considerably extending this limit.

Closed Cycle

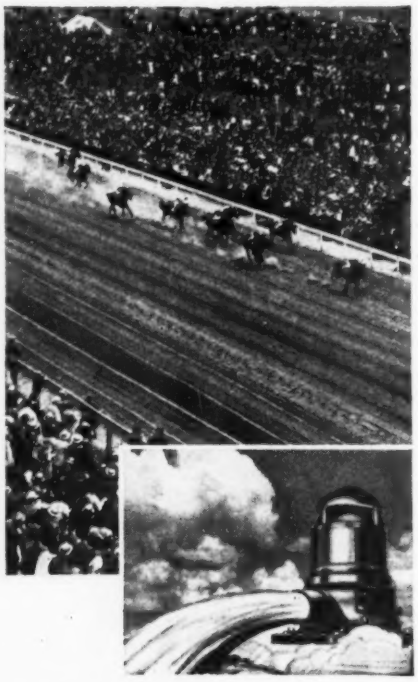
The closed cycle offers a method of increasing the maximum capacity of the open cycle. The volume of the working gas is inversely proportional to the absolute pressure. If the pressure

TABLE 3

Possible combustion gas turbine applications

Industry	Application	Possible fuel	Comments
1. Aviation	(a) Jet propulsion (b) Booster for piston engine (c) Propeller drive (geared or electric)	Gasoline Kerosine	The small, lightweight, gas turbine appears to have a bright future in aviation because of the tendency toward power requirements beyond the practical maximum for piston engines. Much work has been done the world over, burning gasoline and kerosine.
2. Railroad	(a) Locomotive (electric or geared drive)	Coal, bunker "C" oil, or diesel oil	One of the biggest problems in this field is combustion. First, diesel oil, later bunker "C" oil, and ultimately coal must be burned. Electric drive promising. Geared drive presents special problems because of the reversing requirements.*
3. Marine	(a) Marine vessels (electric or geared drive)	Diesel oil or bunker "C" oil,	Possible diesel oil burning turbine electric propulsion equipment will pioneer. The geared drive will follow when reversing and other problems have been worked out.*
4. Central station	(a) Fully automatic booster station at end of transmission line. (b) Standby plant for hydro installation. (c) Standby or peak load plant for small system. (d) In locations where water is not available.	Diesel oil, bunker "C" oil, or coal	The development of the gas turbine in the central station field will probably start along the lines of intermittent duty applications such as (a), (b), or (c) and may culminate in plants for continuous operation.*
5. Industrial	(a) By-product power (b) Standby plant to steam or purchased power where power shutdown is disastrous. (c) Main power source for seasonal industries. (d) Peak load plant, supplementing steam or purchased power. (e) Main power source in low use factor applications such as large laboratories. (f) In a two fluid cycle with one objective, the generation of process steam.	Diesel oil, bunker "C" oil, or coal	Probably continue present developments for operation in conjunction with processes for oil refining.*
6. Special	(a) Bombproof power plants.	Diesel oil or bunker "C" oil	A 4000-kw. plant of this type was built at Neuchatel, Switzerland, in 1939. The fact that no condensing water is required makes the gas turbine ideal for such applications.

*For applications such as 2, 3, 4, and 5, it may sometimes be desirable to depart from the single-shaft arrangement and utilize a two-shaft arrangement in which the compressor is driven by one turbine while a separate turbine drives the generator or other apparatus.



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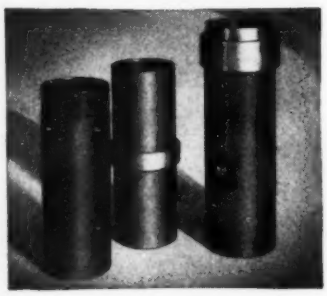

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is multiplied by 10, the size is divided by 10. In the closed cycle, the circulating working gas is at a relatively high pressure and reduces the physical size of compressor and turbine. To reduce the temperature of the gases before they enter the compressor, cooling water is required in the closed cycle. The heat exchanger in which the gas is cooled before it enters the compressor is called a gas precooler. The amount of heat given up to the cooling water is equivalent to that removed in the condenser of a steam unit of equal capacity. The quantity of cooling water required will be less, as a higher water temperature rise is permissible.

The closed cycle in Fig. 11 is the one used by Escher Wyss.[4] This is an externally fired cycle in which the products of combustion do not pass through the gas turbine and compressor. The working gas (air, hydrogen, or other medium) operates at a relatively high pressure in a closed recirculating circuit. In the gas heater, the heat from the products of combustion is transferred to the working gas, which then expands in the turbine to a lower pressure. The gas heater in this cycle corresponds to the steam boiler in the steam cycle. For a practical efficiency, it will be larger than the modern steam boiler because gases are on both sides of the gas heater. This cycle is very similar to the steam cycle except that the working fluid does not undergo a change of state. As this closed cycle keeps the products of combustion out of the turbine and compressor circuit, the problem of using coal as a fuel should be much simpler of solution than in those cycles that circulate the products of combustion.

Hydrogen Has Advantages

In the closed cycle, the compressor inlet pressure will be maintained at approximately 150 lb. per sq. in. with a discharge pressure of some 600 lb. per sq. in. This high pressure greatly reduces the size of turbine and compressor and should permit maximum ratings to be built approaching those in the steam cycle. Some gas other than air will probably be used as the working medium in the externally fired closed cycle. Hydrogen, for example, has properties that make it far superior to air for this application. The density of hydrogen is 1/14 that of air, the specific heat is 14 times that of air, and the thermal conductivity is 6.8 times that of air.

New Cycle Studied

A closed cycle system under development by Westinghouse is shown in Fig. 12. In this closed cycle a separate gas turbine and compressor are used to pump up the cycle on which the main gas turbine and compressor operate. High pressure of about 600 lb. per sq. in.

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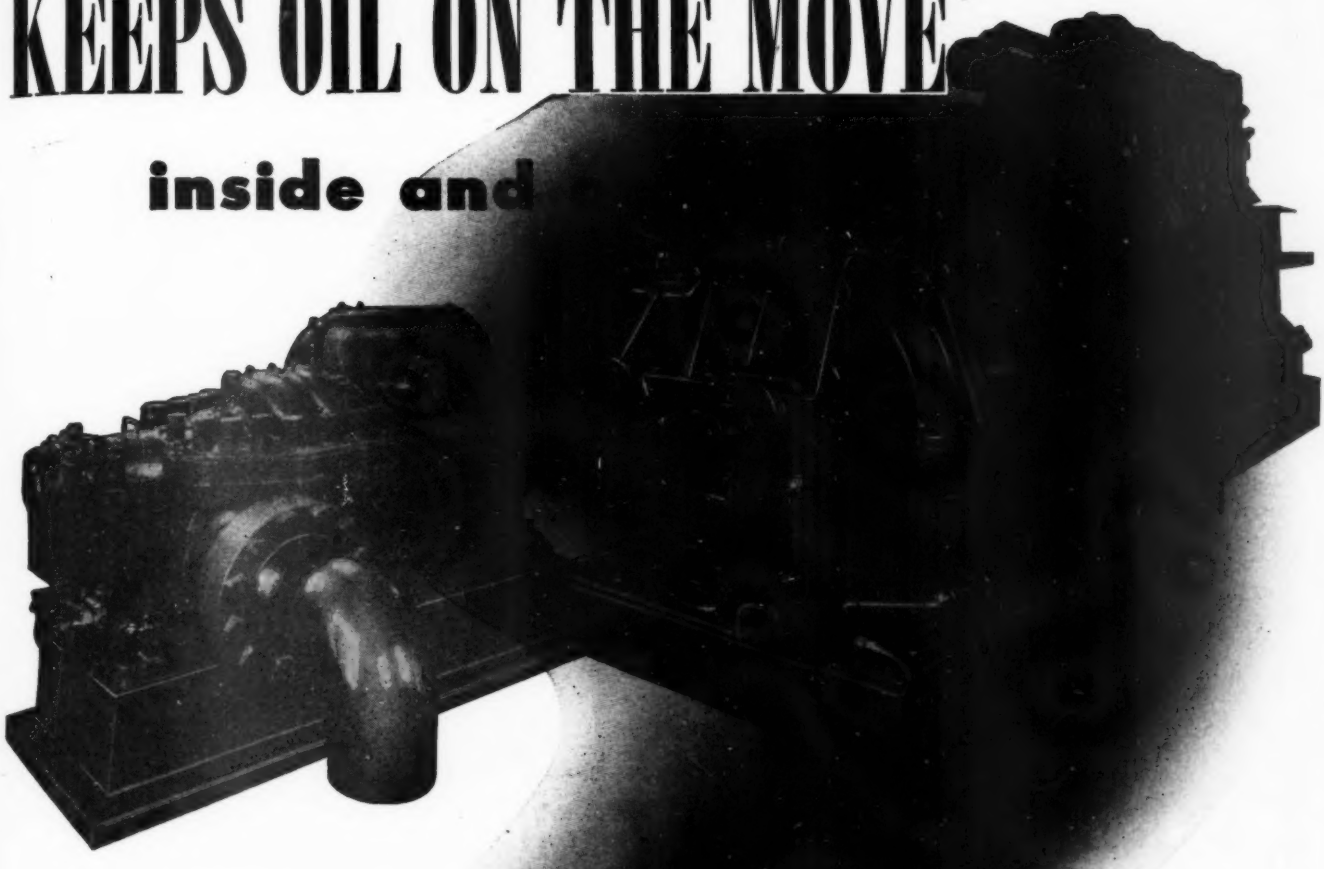

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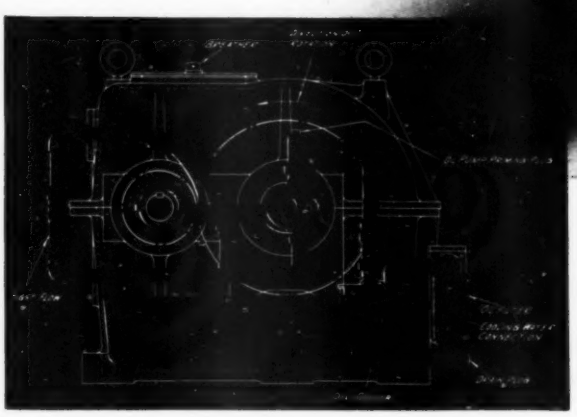

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GEARED DRIVES

may be used with a compressor inlet pressure of about 150 lb. per sq. in. The main gas turbine and compressor would be small as they operate at high pressure. This cycle is internally fired, the products of combustion passing through the gas turbines and main compressor. Enough make-up air is continually supplied to maintain pressure and support combustion. It is supplied by a compressor driven by a second gas turbine. This cycle avoids the large gas heater required by the Escher Wyss cycle but requires an extra gas turbine and compressor to pump up the system. Solid matter from the fuel must be removed.

In the closed cycles shown in Figs. 11 and 12, reheating and intercooling are not illustrated. They offer the same advantage in the closed cycle, however, that they offer in the open cycle. The biggest single additional problem in the closed cycle is a method of building practical heat exchangers. The problem is further complicated by the fact that the gases will carry foreign matter from combustion that may both corrode and erode the exchanger and reduce the heat transfer rate by depositing foreign material on the transfer surface.

Gas Turbine Control

Combustion gas turbine control can be simple and reliable, consisting only of control of the gas temperature by regulating the rate of fuel supply. Governing valves, such as used in steam turbine control, are not needed. Efficient partial load performance can be obtained by using two turbines, one variable speed turbine driving a compressor plus a constant speed turbine driving a generator. (See Fig. 13.) The use of regenerators, reheaters, and intercoolers, in addition to improving the full load economy, has an even greater effect in improving the partial load economy. In the closed cycle, by reducing the gas pressure as the load is reduced, practically full load efficiency can be maintained at partial loads.

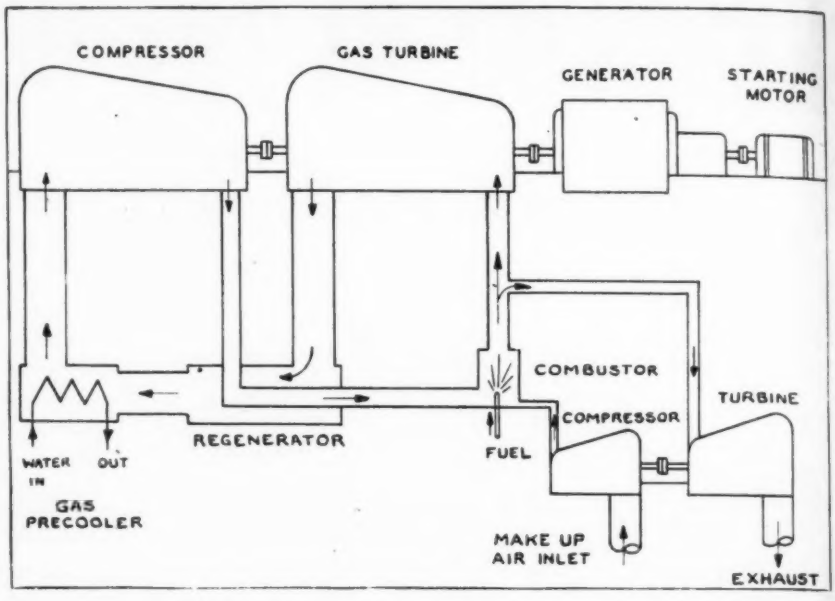


Fig. 12. Proposed internally fired closed cycle

Gas Turbine Applications

Possible applications of the gas turbine are many, ranging from a simple open cycle for small capacities to a closed cycle for very large ratings. For example:

Locomotives. The simple open gas cycle requires no water. It has low weight and small space requirements combined with simplicity. With an efficiency of 20 per cent at 1200°F. and the expected low maintenance of turbine drives, it should prove a good power plant for a locomotive. The inability of the gas turbine to operate in reverse makes either electric drive or the development of a satisfactory reversing gear necessary for this application.

Airplanes. For relatively small power outputs, such as required by the airplane industry, the gas turbine operating at high speed and high temperature to obtain maximum rating per unit weight of material, has real possibilities.

Ship drives. The combustion gas cycle offers efficiencies equal to the best modern marine steam power plants, which have overall efficiencies of approximately 25 per cent. Weight and space requirements of equipment are a real factor in this application. The gas cycle eliminates the steam generator and steam condenser. Despite the weight of and space needed for the gas compressor, the regenerator heat exchanger, and the large gas turbine, the gas cycle has the advantage of being lighter and smaller. The requirement of astern operation in marine service handicaps the gas turbine, except as an electric drive.

Power. General application of the combustion gas cycle in the power gen-

Fig. 10. Efficiencies compared for best practical steam power plants and combustion gas turbine plants

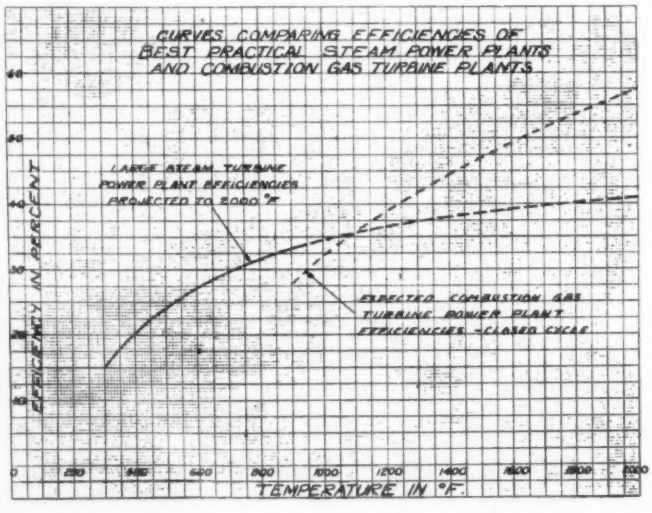
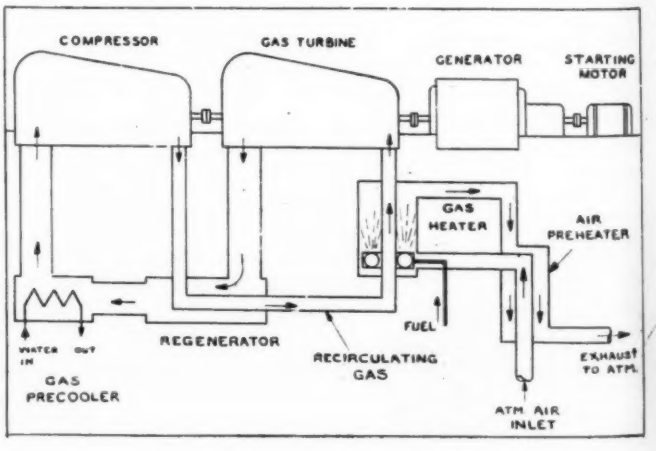


Fig. 11. Escher Wyss externally fired closed cycle



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eration field will probably not take place until the problems in connection with the use of coal as a fuel are solved. The successful development of the closed cycle is necessary if units of very large capacity are to be built. The maximum capacity for which units can be built in the open cycle will include the majority of industrial applications. There are many special applications in the power generation field in which the open gas cycle will possibly find early application. Examples are emergency standby service and low first cost units on the ends of transmission lines. Here a simple open gas cycle offers many advantages, such as no water required, low first cost, simplicity, small space requirements, and virtually automatic station with few attendants.

Processing. In the industrial field, where both power and process steam are required, the gas turbine has possibilities. It fits well in those applications requiring relatively small steam in relation to the power load. This is different from the extraction steam turbine in which large quantities of process steam per kw. are necessary to attain a comparably efficient cycle. Here again, the use of coal as a fuel is necessary for a wide general application.

Other details on these and other possible applications are given in Table 3.

Many Problems Ahead

In drawing conclusions, it should be remembered that the cycle has only had practical application in very special cases. The full possibilities of any cycle can only be evaluated from successful proof of its economy, first cost, maintenance cost, and reliability. The addition of elements that improve the fuel economy and arrangements of the cycle for large capacities are obtained at a sacrifice in simplicity and at a price. The development of the best system is expected to be costly in time and money.

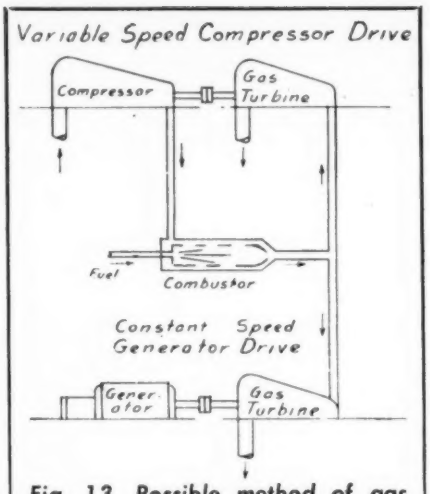

Fig. 13. Possible method of gas turbine control combining variable and constant speed drives

Metallurgy plays an important part in the gas cycle as the efficiency increases rapidly with increase in top temperature. To obtain materials suitable for operation at higher temperatures the metallurgists are looking at materials similar to the non-forgable and non-machinable tool steels. The method of forming these alloys to shape, such as precision casting to size, may revolutionize accepted methods of manufacture. To apply such materials their additional first cost and manufacturing cost must be justified. Any application of such materials must be preceded by careful tests. For heavy duty apparatus these tests must extend over long periods before the designer can use them with safety. Careful differentiation between applications as to required length of life of apparatus is necessary. The fact that a piece of equipment is operated at 1800°F. for a life of a few hours does not mean temperatures of that order can be used for heavy duty applications.

Present developments of the gas turbine are limited to the use of relatively high grade fuel oils. This one factor is a serious handicap to the gas cycle. There is considerable evidence that oil is being used at a greater rate than new supplies are being found. So in the postwar period necessity may dictate a prime mover that can use coal as a fuel. The gas cycle is definitely limited in application until such time as the problems in connection with the burning of low grade oil and coal are successfully solved.

Present research efforts are being expended in developments for national defense. In the postwar era industry will have access to the developments in the gas turbine field and to developments in high temperature materials. These developments may considerably change present thinking. It is safe to predict that general applications of the gas cycle must wait until the postwar era.

It will be wise to watch the developments of the early installations before attempting to make widespread applications. At present, conclusions on the ultimate possibilities of the gas cycle are little more than good guesses. The gas turbine art must advance beyond its present early development stages before it can be judged with assurance. Undoubtedly it will find real usefulness in a large number of fields, however, possibly complementing rather than competing with the steam turbine. Just how and where the gas turbine will be applied, only time will tell.

Holding the Bag

"The oil business is a famous absorber. It absorbs taxes. It absorbs transportation cost advances. It absorbs cost of tax collection and administration. It absorbs the heavy expense of handling rationing for the government, which theoretically runs rationing but actually passes the work on to the industry. Here is a case in which it is being invited to absorb the cost of higher raw materials. (Higher crude oil prices said to be possible if advance is absorbed by industry.)

"Washington dispatches say officials are proud of the fact that they have held the line successfully for 15 months. Oil men consider they have been holding the bag for a lot longer than that."

Keith Fanshier in
Chicago Journal of Commerce

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2. "Load Tests of a 4000-kw. Combustion Turbine Set," by Dr. A. Stodola, *Engineering*, January 5, 1940, Vol. 149, pp. 1-4. A 4000-kw. gas turbine electric generating set installed underground as an emergency power supply in a bomb-proof shelter, has been supplying the city of Neuchatel, Switzerland, with some electrical energy since early in 1940.

3. "Experience Refines Velox Boiler Design," *Brown-Boveri Review*, August-September, 1941. One of the earliest applications of the combustion gas turbine has been in connection with the Velox forced circulation boiler. In this application, the compressor supplies air to a boiler combustion chamber under approximately 35-lb. pressure and the products of combustion from the boiler expanding through the gas turbine permit the gas turbine to drive the compressor.

4. "An Aerodynamic Heat-Power Plant," *Escher Wyss News*, 1939, No. 1-2. Escher Wyss, a Swiss firm, has an industrial plant using a special closed cycle in which the products of combustion do not pass through the turbine. It states this cycle has an efficiency equal to that of an up-to-date steam plant.

5. "Portable Power from Gas Turbines," *Power*, April, 1941, pp. 96-97. In this country, a number of gas turbines have been applied in connection with processes for oil refining. In this application, the compressor supplies air to burn carbon from the catalyst used in the cracking process and the products of combustion (at a temperature below 1000°F.) expand through the gas turbine, enabling it to drive the compressor and also supply some energy to a generator.

6. "Gas Turbines and Jet Propulsion for Air Craft," by G. G. Smith, *Flight Publishing Company*, London, England, June, 1943, p. 38. In the English literature there has been considerable discussion of the combustion gas turbine in connection with jet propulsion of aeroplanes. Of all applications, jet propulsion of planes is undoubtedly the most intriguing. Most countries are interested in this development but the Italians are the only ones who have published any information. They made a successful flight on August 27, 1940, with a high speed aircraft using jet propulsion. The machine was driven solely by the reaction of the ejected gases and was said to be the prelude to a revolution in the design of aircraft and power plant installation.

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Arabian Oil and American Policy*

☆ Middle Eastern petroleum wealth has created curious and complex relationships

by Dr. Herbert Feis

Economic Adviser, U. S. Department of State

THE sandstorm that has blown up around the oil of the Middle East is dangerous and unnecessary. In its obscure depths nations can easily lose their way. Each moving figure takes on a strange aspect and around every campfire rumor keeps excitement high.

The sands were first stirred by allegations that the Middle Eastern oil resources controlled by other countries, were not being used in fair measure, while the reserves of this hemisphere were being drained in the conduct of the war. Hardly had they settled when the announcement came that this government, by agreement with the American companies who hold concessions to develop oil deposits of Saudi Arabia and Kuwait proposed to build and operate a pipe line from these fields to the Mediterranean. It is this project, in particular, that I propose to discuss today.

This project commanded the startled attention of all the diverse and powerful interests that converge in and upon the Middle Eastern oil fields. First there are the great commercial interests. No man knows what the ultimate underground reserves may be of the lands lying between the Mediterranean, Red, Black, and Caspian Seas, and the Persian Gulf, or of the various separate fields within it. Actual drilling has taken place only in a few points of selected structures. Fewer wells have been drilled in the whole area than in any minor American field—such as Kansas where the wildcatters pursue their hopes. Except in a few sources of well established production, as in southern Iran, even geological examination of the structures has not gone far beyond preliminary survey. But various recent estimates, as expert as any estimates can be that rest upon such evidence, encourage the prospect that the ultimate resources of the area are at least as great as all the reserves that remain within the United States. Further, the great average yield of the drilled wells indicates a low production cost. This measures the financial interests of the oil companies that hold the right to develop and sell this oil, and of the peoples in whose territories they lie.

The concessions are divided among various large oil companies, American and foreign, in a pattern of financial and commercial relationships as complex and irregular as were the land holdings within villages in feudal times. They are almost as difficult to untangle as a scene on a football field at the moment of a forward pass; it is not always easy to know on which side the individual players are, who is tackling whom, and for whose hand the ball is intended. The important oil fields of southern Iran are operated by the Anglo-Iranian Company, in which the British government holds a controlling place. The various fields of Iraq, Palestine, and Qatar are among the exclusive concession rights of the British-Dutch-American-French combination known as the Iraq Petroleum Company, in which the British groups have the ruling power; the Standard Oil of New Jersey and the Socony Vacuum are the American participants in this combination. Other American oil companies, the Standard Oil of California and The Texas Company, combined in the Arabian-American Company, own the concession to the promising areas of Saudi Arabia and Bahrein. The Anglo-Iranian Company and the Gulf Oil Company are in equal, and mutually restricted, partnership in the sheikdom of Kuwait. These are the principal details of the intricate pattern of interests that exists.

Each of the companies looks to the same main markets—Europe, the Mediterranean basin, India, and the Far East. Each is made unquiet by any step that might affect its control over its properties, its prospects of production, or its relative marketing opportunities. Each is open to resentment or envy of what it may deem preferential governmental assistance extended to others. Quarrels among them could have far more than the usual commercial consequence. It could strain the bonds of the combinations whereby American and foreign interests adjusted their operations, and create renewed dispute about the rights they control. It could stimulate competitive diplomatic activity by the governments to which the companies may look for support. It could provide excellent opportunities for those who seek to fish in troubled waters.

The local governments are similarly interested in every new event of consequence. The oil bearing resources lie under the territories of small and predominantly Arab states whose names ring in American ears with remote romance—Iran, Iraq, Palestine, Saudi Arabia, Bahrein, Kuwait, and Qatar. Some are independent, some mandates, some dependent little sheikdoms. Under the agreements negotiated with the oil companies, their local sovereigns obtained royalty rights in general proportionate to the volume of production. In each, therefore, there is a natural eagerness that production within its realm be carried forward so that the treasuries may be enriched. Since oil from the various fields would largely serve the same markets, each must follow with interest the question of whose oil prospects benefit from any undertaking. The outlook for their income is involved and connected therewith in some states, relations with tribal groups, and ability to maintain themselves against disorder and to sustain military forces. Thus, each is alert to any development that may affect the status of his country.

Watching the whole situation are the great powers concerned with the political control and tranquility of the region. Traditionally, Great Britain, by a far-flung system of agreements and political agents, has claimed primary interest and influence, and has striven for the maintenance of order and freedom from outside political ambitions and intrigue. Before the last war Great Britain was forced by Germany to the edge of sharing its controlling interest. In Iran, Great Britain and Russia have intermittently contested for place and control. In the Declaration of Teheran they have now joined with the United States in a pledge of Iranian independence. The French government has clung to its mandate in Syria and Lebanon throughout its period of disaster; French interests hold a quarter share of the Iraq Petroleum Company, and one branch of the present pipe line has its terminus in Tripoli. These interests France is deter-

(Continued on Page 138)

*Paper presented before the Foreign Policy Association, New York City, April 15, 1944.

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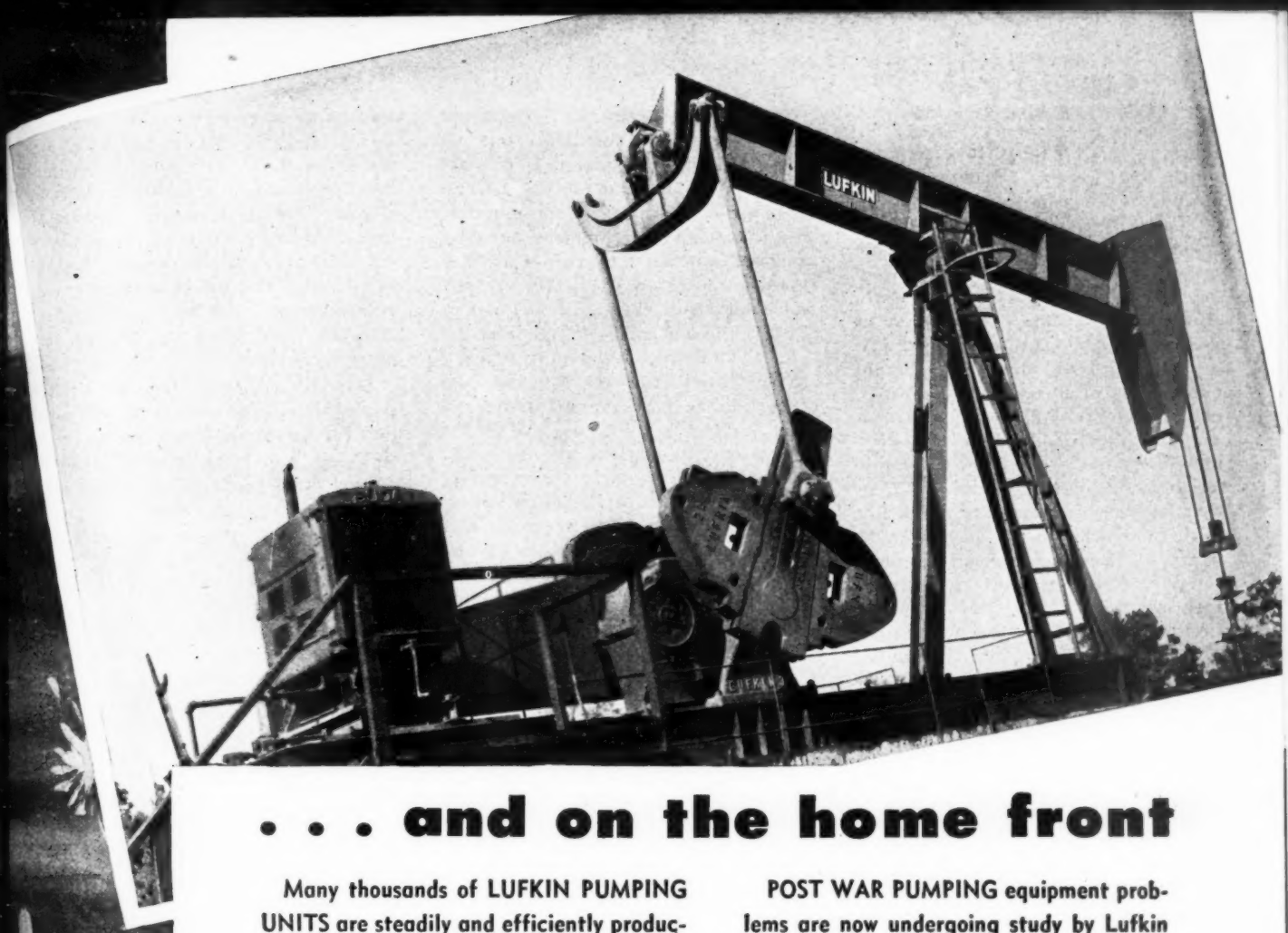

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(Continued from Page 135)

mined to guard. Each of these powers is on the alert lest engagements made regarding oil affect its position.

Such is the web of converging political interests through which the pipe line project must find its path. Small wonder then that the way in which the American government announced its intentions set all alarm bells ringing. It was a dramatic and somewhat blunt announcement of an agreement in principle between the American government and the American oil companies possessing concessions in the most promising oil territories in Saudi Arabia and Kuwait for the construction of a pipe line from their fields to the eastern Mediterranean. The announcement was made before the completion of arrangements with the local states through whose territories the pipe line will run; though it did explicitly state that the project was conditioned upon obtaining the sanction of their rulers. It was not, as far as I know, communicated in advance to any other government, or to any of the other oil companies whose operations might be affected by it.

The surprise was particularly marked in Britain, which traditionally has regarded the area as within its sphere of influence. Further, the project immediately raises certain questions of treaty relations and obligations between the British and local government, and certain agreements between American and British companies as well. In Kuwait the sheik is obligated not to sign political agreements or to grant oil concessions to any foreign government without the consent of the British government; whether this applies to the pipe line construction is a matter that awaits clarification. Then, too, in the ownership of the Kuwait concession, the Gulf Oil Company is in full, though mutually restrictive, partnership with the Anglo-Iranian Oil Company in which the British government holds a controlling share. Further, in all probability the pipe line would traverse and have its terminus in Palestine, a British mandate, or enter Egypt.

So much for the elements of interest in the situation of which account must be taken. What of the project itself? What sound purposes could it be made to serve? What advantages would it convey to the United States and other countries? What disadvantages and dangers may be connected with it?

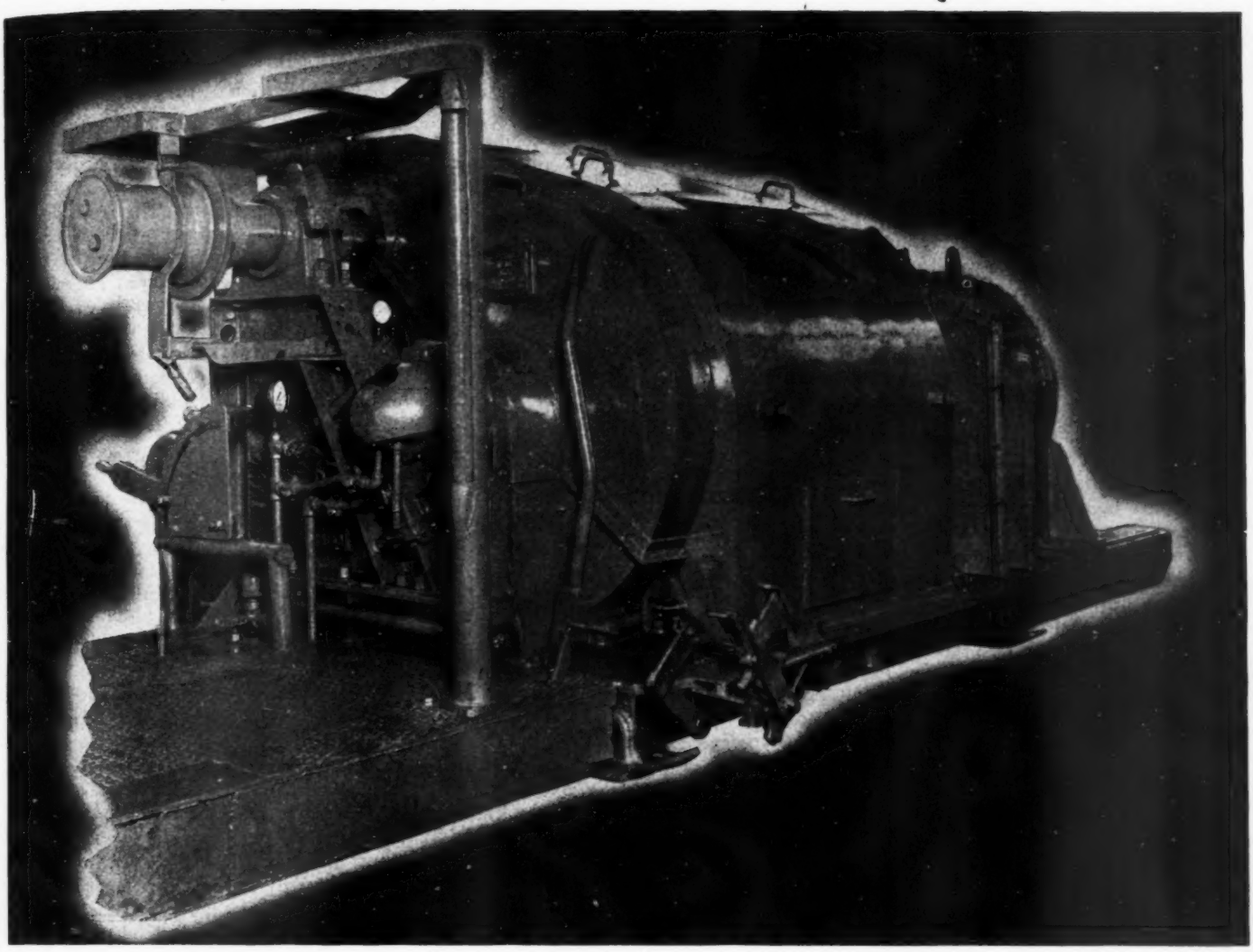
The primary justification of the project from the American point of view arises out of the advisability of bringing about a great increase in the production of oil in the Middle Eastern fields. This source of supply would help to meet world demand and thus safeguard the reserves of this hemisphere. Our situation warrants us in facing the future with calm confidence but not with complacent indifference. We have drawn prodigally upon our own reserves —for ordinary domestic consumption, for export and for military use ourselves and for our allies in two wars. But known underground reserves are still substantial—in the neighborhood of 21,000,000,000 bbls. on the basis of present knowledge. Supplies from many foreign fields, whether controlled by American or foreign enterprise, are available to us. We possess also all the raw materials—natural gas, tar sands, shale, cannel coal—for the manufacture of synthetic petroleum in whatever quantities might be required. This would necessitate an enormous investment and the product would be several times more costly than natural petroleum.

But American production has been and remains far out of proportion to its share of world reserves and recently the rate of use has exceeded new discoveries. It is imperative that the drain upon these reserves in the future be not so great as to leave us vitally dependent at any time upon foreign resources, or short of the supplies that would be necessary should we ever again be engaged in a war like the present one. The alternatives are to develop an enormous petroleum manufacturing industry, or to minimize the future demands on our own production by bringing about increased production in other lands. The second is the better course. For it is the more economical, and it may yield great benefit to other nations as well as to ourselves.

The construction of the Trans-Arabian pipe line might well be an important step towards this end. The Middle Eastern oil fields are capacious enough to supply a substantial part of the world's future requirements, and the pipe line would, directly and indirectly, bring about an extension in the use of its product. It would open up new markets for the oil of Saudi Arabia and Kuwait. It would almost certainly stimulate, because of competitive circumstances, other pipe line construction to the Mediterranean and the Persian Gulf, and bring about an enlargement of tanker fleets and possibly of refineries. An indication of this tendency is the request made some time past by the oil companies combined in the Iraq Petroleum Company for material and equipment for the construction of another pipe line from their fields to the Mediterranean. In such ways as these the construction of the pipe line would hasten and enlarge the entry of Middle Eastern oil into world markets to satisfy a rising world demand. Europe and the Far East, in particular, would gradually shift their source of supply, satisfy more and more of swelling requirements from the Middle East. The resources of the United States and of this hemisphere would be drawn on in correspondingly less amount; saved for a longer future. This is the most probable advantage of the pipe line undertaking—by the government or the companies or both. It would help to safeguard our domestic supplies for peace or for war.

But the official explanations have tended to indicate another type of military reason for the government initiative—not merely the preservation of assured accessible supplies. They have tended to suggest that this Middle Eastern oil itself might be regarded as a permanent military reserve similar to those underground reserves that have been set aside within the United States. There is a provision in the agreement, of which much was made in the original announcement, whereby the companies obligated themselves to keep underground at least one billion barrels for purchase by the American government at a favorable price. This provision, itself, has little practical importance. The prospect that the underground resources of Saudi Arabia and Kuwait would be exhausted by commercial or other demands during the life of the concession is small and as long as the oil was there and as long as our armed forces were in a position to get it, they would in time of war have a prior claim.

The military usefulness of any source of supply is entirely dependent upon its location. Thus the value to us in wartime of Middle Eastern oil is entirely conjectural. It would be determined by the military and political circumstances that ruled. If our forces, or those of our allies or friends, controlled the fields and pipe lines, and our ships and planes had access to them, these supplies might be of the greatest use. If, on the other hand, our enemies controlled them, or could prevent access to them, they would serve only to injure us. Such, alas, turned out to be the fate in this war of the fields in the southwest Pacific that American, British, and Dutch capital developed. Certainty can only be obtained if adequate arrangements could be made to assure military control of the producing areas in time of crisis. One way of achieving this might be the establishment of a United Nations naval base in the region that would both afford protection and, perhaps, transform Middle Eastern oil supplies into a great source of supporting strength for international order. But I know of no project of this kind. It would be feasible only if the nations combine in a firm underlying political system for the adjustment of their disputes and the maintenance of peace and



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effective only if the system stood up in the test of future crises.

Still another reason advanced for American government initiative is that it would make more secure the existing American private control over the oil resources of Saudi Arabia, Kuwait, and Bahrein. Here one encounters a mist of rumor and suspicion. The American companies operating in these countries have been susceptible to a variety of apprehensions. There has been fear lest changes in the government or dynasties of the local states might lead to disturbance of their rights. There has been fear that local sovereigns might seek to meet continuing deficits by very burdensome requests for loans or advances and that the consequence of refusal might be impairment of the concession. There has been suspicion that foreign interests, commercial and political, were striving to dispossess them—stimulated by active rumor, supporting evidence of which proves elusive to the diligent detective. There has been fear of the consequences of possible territorial changes that might occur at the end of the war.

It is impossible to foresee the hazards that might appear on the screen of the future. The entry of the American government into the situation through the pipe line undertaking is intended to provide a safeguard. How adequate it would be cannot be foretold and what decisions it may place before the American people is at the very heart of the dispute over the wisdom of the undertaking. The existence of a pipe line owned by the American government, operating in intimate relationship with the American-owned producing properties in Saudi Arabia and Kuwait might well make the American oil properties less vulnerable to possible attempts to disturb their position or to oppress them. The construction of the pipe line itself will bring increased income to local treasuries and peoples and the extension of production will result in a permanent increase. In these ways American control of the properties might be made more secure. But it remains impossible to foretell how effective the peaceful means of protection possessed by the government would be in some future situations and whether they would suffice to provide protection against any major storm of change.

The foregoing, then, constitute the valid reasons that lend support to a pipe line project.

To what criticism or objection is the proposal open? A question may be raised as to whether the proposed agreement would give the United States government sufficient influence in the actual development of the oil fields to assure the attainment of its ends. This applies particularly to production policy, arrangements between companies, and the conduct of relations with the local governments. The companies will, it is true, be obligated to tender to the pipe line quantities of oil large enough to assure repayment of the government investment; this in itself would mean a substantial increase in production. There is also to be a provision that "the commercial and other policies of the companies would conform to the foreign policies of the United States." The adequacy of these provisions should be further studied.

I turn now to the main causes of concern over the proposed undertaking. The American government as sponsor-owner of the pipe line (and of other properties that may be required for its full and efficient operation) places itself in the center of a complicated struggle of interests and purposes. I have already tried to indicate how great is the convergence of interests—commercial and political—upon the Middle Eastern oil fields. Each company and government concerned will be on guard to see that its position is not disturbed; will struggle to protect itself against any adverse development and to secure a full share of any favorable one. The waves of controversy might touch shores distant from the Persian Gulf. The companies possessing oil production in the Southwest Pacific are, for example, no doubt wondering how their place in the markets of the Far East may be affected. Should the U.S.S.R. in the postwar period seek export markets for Russian petroleum production it would display a similar interest.

Should a struggle arise, the responsibility of the American government would be engaged. This would be so even though the pipe line was constructed for the government by the Arabian-American Company and would still remain so should the government decide to entrust the actual operation of the pipe line to that company. For the government will have to dig the diplomatic trench in which the pipe line is laid. It will be believed to possess final influence in the pipe line venture and almost certainly would steadily exercise influence in its behalf. The British government is judged responsible throughout the world for the policies of the Anglo-Iranian Oil Company on less extensive and obvious grounds. These possibilities of disturbance in our foreign relations dictate a serious effort to foresee potential difficulties and to forestall them by agreement. They indicate the clear need for a program in which all concerned will possess a concerted and adjusted interest.

However, current doubt has not attached so much to the conflicts of interest that might arise out of the installation and operation of the pipe line itself as over the possibility that the need to defend an important government property interest in that part of the world might confront us with a choice between national humiliation and the use of force. As matters now stand both national interest and international law would permit the extension of government protection to privately owned American oil properties in the Middle East by peaceful means, within the limits of equity and practicality, against unjust and unprovoked injury. But the companies would be expected to manage their own problems to the greatest possible extent and make their own compromises. Decision as to what measures, if any, were justified, equitable, and advisable would be entirely within the discretion of the government and public opinion would tend calmly to let it judge the public interest.

Government title attached to the pipe line should not affect the standard of correct decision. However, it might well do so. The existence of direct government interest might lead to a more excited and unthinking estimate of what public interest was at stake in any controversy. It might be more difficult to arrive at a compromise adjustment. Incompetent diplomacy might the more easily appeal to national feeling to cover up its incompetence. Aggressive diplomacy might find the pipe line project a convenient excuse for other ends and lead into a political crusade in that part of the world under the guise of safeguarding vital oil supplies.

It would be unfitting and unwise to be governed by self-mistrust or anxiety. But it would be careless error to assume risks not essential to the public welfare, or to neglect any possibility of lessening them.

Thus the judgment is led from all sides to the conclusion that if the American government proceeds with the pipe line it should simultaneously take steps to assure that this will not provoke disturbance and conflict in the Middle East and to minimize the dangers of later controversy. These steps should be designed to bring about a coordinated program of development of all the fields of the Middle East by cooperation between all interests concerned, not only for our benefit but for that of all countries. It should make this oil accessible on equal terms to all countries. If the government is not prepared to take the lead in an accord of this kind it had better leave the pipe line to the companies. If its commercial prospects are as good as they appear to be its con-

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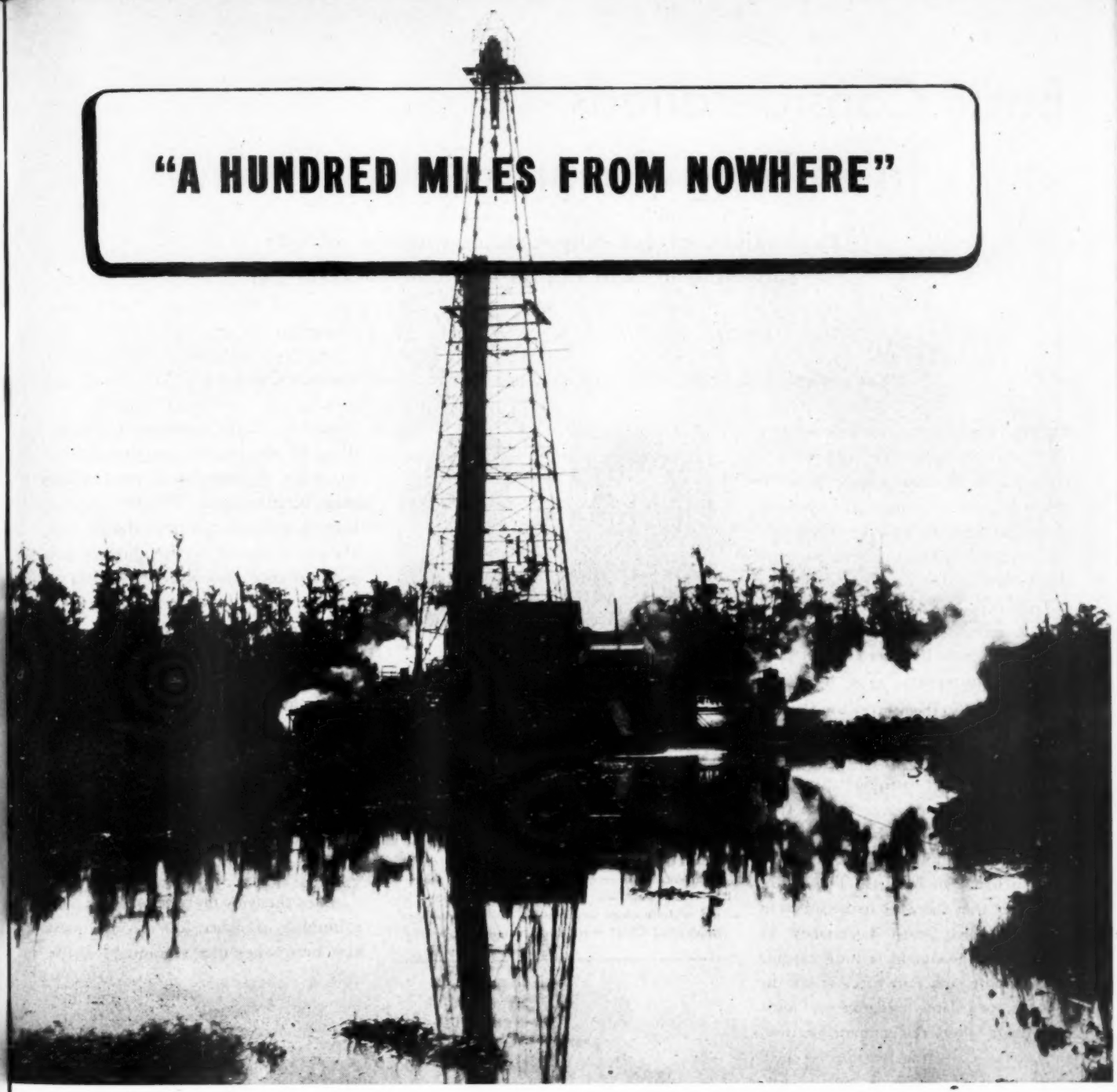

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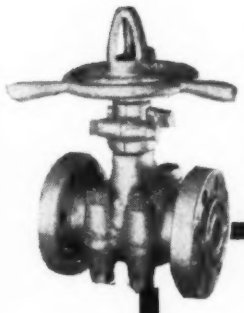

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Basic Considerations In A Tong Program

☆ Analysis of use requirements governs latitude allowable in both design and construction

by Garth F. Nicolson and M. B. Riordan

Chief Engineer and Chief Metallurgist, Oil Tool Division, Byron Jackson Company

THE many widely divergent uses to which tongs are subjected in every-day field usage impose problems of proper selection upon the operator, if he is to maintain an economic inventory of these tools. On the other hand, the manufacturer is confronted with the necessity of broadening all original tong designs and improving their physical construction in order to meet present-day requirements.

Theoretically, the perfect tong would be one that could be used with equal facility on drill collars, flame hardened tool joints or light casing of any diameter. Practically speaking, no such tong now exists, in spite of the vast amount of time and effort expended in attempting to produce such a tool. This is due to the fact that there are many inherent difficulties, that must necessarily be overcome, in producing a tong capable of developing sufficient force at the die to penetrate a flame hardened tool joint and insure positive gripping action, while at the same time distributing these forces to prevent crushing light weight casing.

The strength of the tong, with consequent added weight, must be such that large size drill collars can be easily "broken out" even when there is present a very considerable angularity of pull. Coincidently, tongs must be light enough in weight to permit of easy handling by the smallest roughneck. Furthermore, the question of tong balance must be considered. Whether the tong is open or latched around the pipe; off the center line of derrick, high or low, good balance contributes to both the ease and speed of operation.

Undoubtedly no tool on the rig is subjected to the continuing abuse "poured on" the tong. Proper lubrication is quite frequently overlooked, yet it is commonly expected that tongs perform properly over long periods of time without any repairs being made. When repair does finally become necessary it is then expected that it can be done in a minimum of time and with minimum expense.

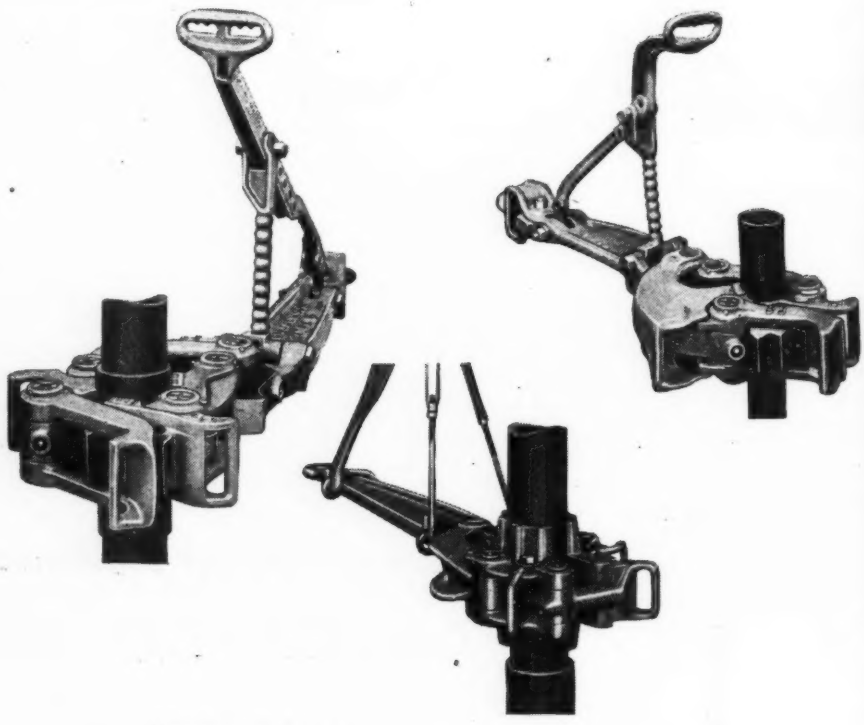
All of these use factors, together with a number of other less obvious ones, have been taken into account by Byron

G. F. NICOLSON

M. B. RIORDAN

Garth F. Nicolson was graduated from California Institute of Technology as a B.S. in M.E. in 1934, and immediately went to work for Byron Jackson Company in the service and engineering departments. He was made Chief Engineer, Oil Tool Division, 1942.

M. B. Riordan took chemical engineering at the University of Southern California, and was graduated with the degree of B.S. in 1939. After spending two years with Wilshire Oil Company on chemical control in refining operations, he went with Byron Jackson Company in the metallurgical department. In 1943 he was appointed Chief Metallurgist of that company.



Upper left—The Type "B" Tong is designed for average to heavy duty on a range of sizes of from 3½" through 10¾". Upper right—The Type "C" Tong is for workovers, slim hole and other light rig operations handling diameters of from 2⅜" through 8⅝". Lower center—The drill Casing Tong is a perfect bore tong with a full 12" bearing face, for any specified casing and coupling size.

(Advertisement)

Jackson Co. in the development of their present line of tongs and tong dies. Generally speaking, two types of tongs cover major requirements of the average drilling job. The type "B" tong is designed for heavy duty and will fit any diameter from 3½ in. to 10¾ in. by incorporating three extra lug jaws. The type "C" tong, for lighter service, can be made to fit all sizes from 2⅜ in. to 8⅝ in. by incorporating extra lug jaws. Beyond this range of sizes experience has proven the advisability of the use of special tongs both in the drilling and casing program.

Multi-range and in many cases single size drilling tongs are liable to crimp casing even though maximum care is used. Therefore, it would appear that special casing size tongs should be used if damage is to be prevented. Special casing tongs, light in weight, each fitting a short range of sizes, could be provided to cover the casing sizes commonly used. In such tongs jaws could be built integrally thereby eliminating the possibility of installing, in the field, jaws of different bores, with the consequent possibility of casing crimping. From an economic standpoint such a program would prove feasible due to the long life such special tongs would enjoy, the reduction of die consumption to an absolute minimum, and the insurance which would automatically be provided any casing program.

The increasing use of casing as drill stem instead of regular drill pipe has necessitated the development of drill casing tongs. These tongs are provided with 12 in. bearing surfaces and are bored to give perfect contact around the full circumference of the drill casing — again to preclude any possible crimping action.

In order to accurately determine strength, weight and balance required for these several types of tongs, electric strain gages are employed. Directional stresses and their magnitude, when obtained by means of such a test, clearly indicate the sections of the tool requiring increased strength or weight. With such determination carefully analyzed, it is possible to work out a redistribution of both material and stresses enabling the production of stronger yet lighter weight tongs. Once stress conditions have been established it is possible

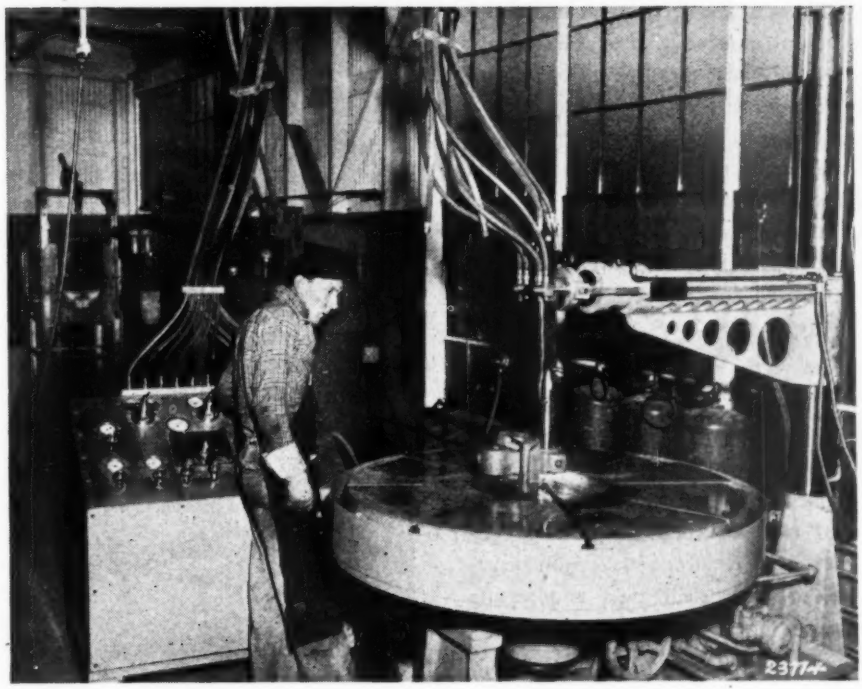
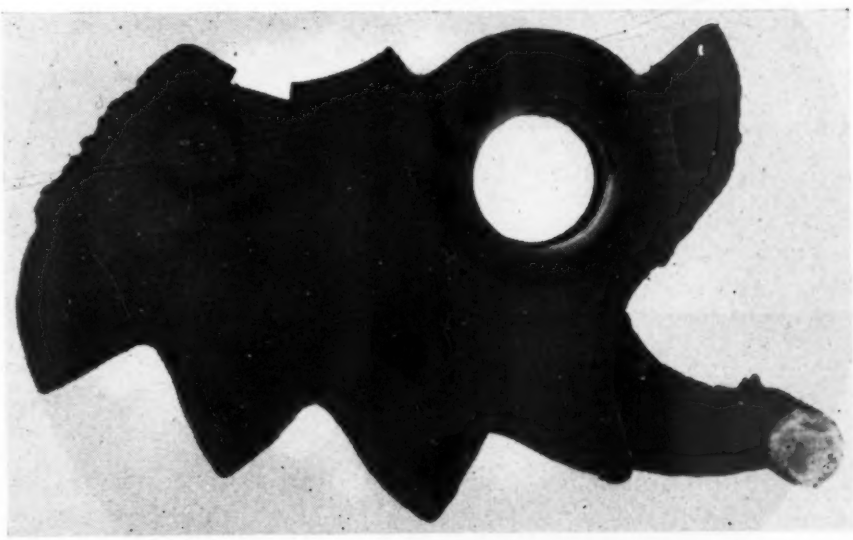


Illustration shows BJ Flame Hardening Machine used in treating hinge pin holes of BJ Tongs



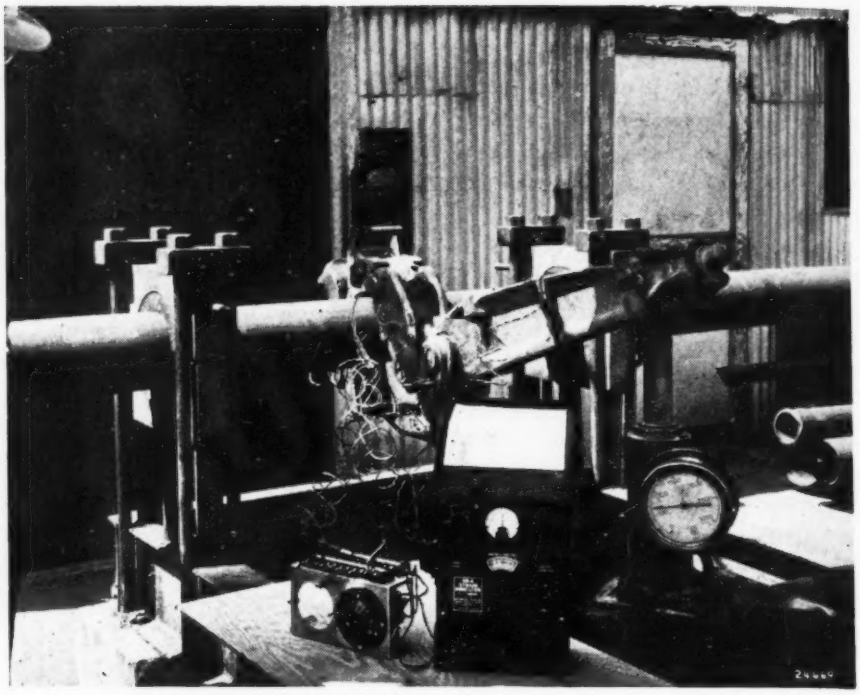
Cross section of latch lug jaw. Note heavy case around hinge pin hole due to flame hardening.

(Advertisement)

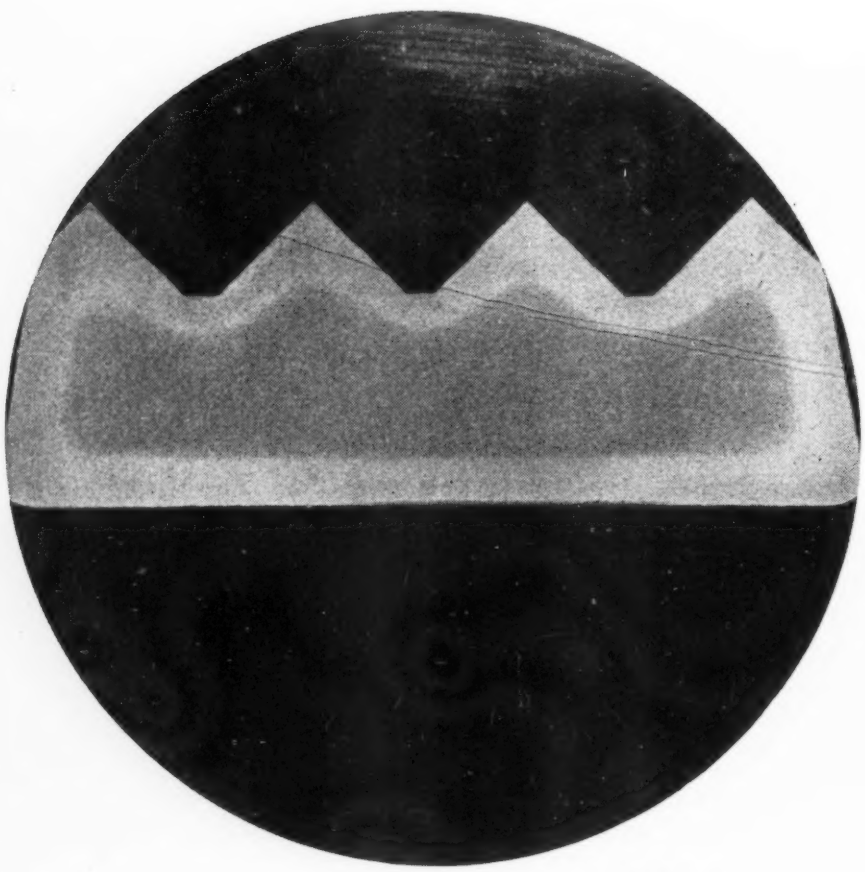
to determine the materials which should be used in construction of the tong and the proper heat treatment of the various component parts. An outstanding example is the test-proven wisdom of flame hardening hinge pin holes of the tongs which normally receive the most wear and affect the gripping and general operation as the wear increases. Such flame hardening materially lengthens the life of these holes.

Thus it is by taking all these basic principles into tested consideration that Byron Jackson Co. has reduced the number of tongs required on the rig; provided stronger, lighter, better balanced tools of such design and construction as to afford maximum insurance to both drill pipe and casing strings.

Still another step has been taken. Due to the widespread usage of flame hardened tool joints a newly developed symmetrical toothed BJ Tong Die is now available. These new tong dies have a hard, deep, fine grained case with an extremely tough inner-core. Repeated tests prove that these tong dies have a faster, more positive gripping action with less exerted pressure than heretofore considered possible. Since teeth are symmetrical the die may be reversed in the tong and the life of the die thereby doubled. An interesting bulletin on comparative tests run on dies has recently been published by Byron Jackson Co. and is available upon request from any of their field representatives or the home office in Los Angeles. Correspondence is also solicited along with suggestions of methods for further improving and standardizing tonging programs. Communications should be addressed to the attention of Garth F. Nicolson, Chief Engineer, Oil Tools Div., Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, California.



Showing Strain Gage Test on Type "B" Tong. Note that 650 psi is being applied at lever end. Tongs are fully tested to better than 2500 psi.



New BJ 18 or 21 Tong Die showing symmetrical tooth form, heavy case and tough close grained core.

— ☆ ☆ ☆ —

(Advertisement)

(Continued from Page 140)

struction, though perhaps on a smaller scale, would not be long deferred.

The prospective meeting between representatives of the British and American governments is to be welcomed. It has been announced that the conversations are to start on the "technical" level. Presumably this means that attention will be directed first to matters of immediate import. Among these would be: The definition of the route of the pipe line, and its terminus; the examination of the rights and obligations of the pipe line company under treaties and local law; the securing of British acquiescence or aid in making the necessary arrangements with the local governments, and the determination of its relations with the producing interests, other than the American-Arabian Company. This last would cover many points: The question of whether it is to be a common carrier; the future of the agreement linking British and American interests in Kuwait; the wish of other oil-producing companies to secure materials and equipment to develop other new means of transport for their product.

Agreement between ourselves and the British authorities on these matters would be a promising beginning but only a beginning. The main problems of ultimate importance would remain unless the understandings go beyond such immediate points of interest. The meetings should prepare the way for a general accord between the two governments whereunder they would pledge themselves to use their joint influence to see that the interests of their two countries worked in harmony. Plans should be devised for the orderly development of the area and the adjustment of disputes through continuous consultation. Such an accord should contain no political or military provisions or obligations and it should not commit the governments in regard to the measures to be taken in any future contingency. Such understandings should give place to the governments of the local territories and all other governments having a clear interest in the area. It should contain a pledge that the development of Middle Eastern oil would be available on equal terms to all nations as far as it may be in the power of the United States and Great Britain to fulfill that pledge.

Only an accord of this character would give assurance that the pipe line was more than a dubious adventure, would lessen its risks, and would elevate it into an undertaking that promised benefit to all nations and threatened none. It could be an example of trusteeship for all the United Nations—serving at once their need and our own quest for certainty that our oil supplies will be adequate for any requirements that the future may impose.

☆ ☆ ☆

Proper Maintenance of Air Compressors[1]

P 094.84

PORTABLE compressors are complete air compressor plants including compressor, prime mover, cooling system, control mechanism, and receiver. As such, a few comments on care and operation of portable compressors should be beneficial in insuring long life and highest efficiency.

Assume that a new portable compressor has been delivered and is being put into service. It is a product of a reputable manufacturer and is guaranteed to deliver a specific amount of air at a definite discharge pressure. Proper attention to operating details will insure maintaining the unit's capacity.

Probably the best two suggestions that can be made to insure a long and trouble free life for the compressor unit are these: (1) Assign a specific individual in the organization to be responsible for the operation of the machine and, (2) have that person read and study the manufacturer's instruction book carefully before even attempting to start the unit.

Although portable compressors usually undergo a "break-in run" at the factory, it is not advisable to start a new machine working against full load immediately. Most units, when factory test is completed, are slushed with heavy oil to prevent rust and corrosion in case they are stored for any period of time before being put into service. A good run on the engine, without compressor load, will clear out this oil and help prevent fouling of plugs and gumming of piston rings. Another run, with all the compressor discharge and cooler valves open, will prevent carbonizing of compressor valves and assist in maintaining high compression efficiency.

Proper lubrication, as with any reciprocating machine, is vital. It is important that the correct grade of high quality lubricating oil be used. Follow the manufacturer's instructions relative to quality of oil and frequency of changes. There is nothing so destructive and expensive as inadequate lubricant or poor quality oil.

Necessarily, portable compressors operate frequently in dusty locations. The air is laden with grit and dirt that could be most harmful to a portable unit. For this reason, adequate air cleaners are always supplied on both the compressor and engine inlets. Follow printed instructions relative to servicing air cleaners. Check them frequently. A dirty air filter on the engine will cut down power and increase fuel consumption and clogged compressor air filters will cut the capacity of the machine and make it run hot.

Similarly, most machines have oil filters. Frequent and regular servicing of the oil cleaners will keep lines clear, insure adequate lubrication, and prevent costly breakdowns.

Keep the machine tightened up. A portable compressor, even when towed at no more than the recommended speed, will frequently loosen up. Trace down any rattle and be sure that all the nuts and studs are tight. To minimize this possible source of trouble, stay within reasonable towing speeds; i.e., if steel wheel mounted, keep under 10 miles per hour, if rubber tired without springs, under 15, and if pneumatic tired with springs, within 30 miles per hour.

A portable compressor with a clean exterior is a good advertisement for the company operating it and keeping it clean saves money. If rust spots show anywhere, touch them up. If not attended to they might corrode through and cause trouble. Wash the unit down occasionally. It will look better. Mechanics will take better care of it and, in addition, the washing will clean off heat transfer surfaces, such as radiators, cooling fans, etc., which will help to maintain the original efficiency.

When service is required, if the operator does not know how to make an adjustment, call a field representative. It will be cheapest in the long run to get the job done right. If service isn't available, read the instruction book carefully before undertaking even the simplest job. One wrong adjustment might ruin the machine's performance.

If and when the portable is stored, follow good common sense rules. Drain the cooling water, flush the cooling system, and put in a good rust inhibitor. Drain and flush the crankcases and slush the machine with a good rustproof lubricant. Drain all tanks, paint exposed finished surfaces with a dried grease. Do these things and the portable compressor will be ready for use when it is next needed.

The manufacturer has built a rugged dependable air plant. Give it reasonable attention and care and obtain full value for the investment.

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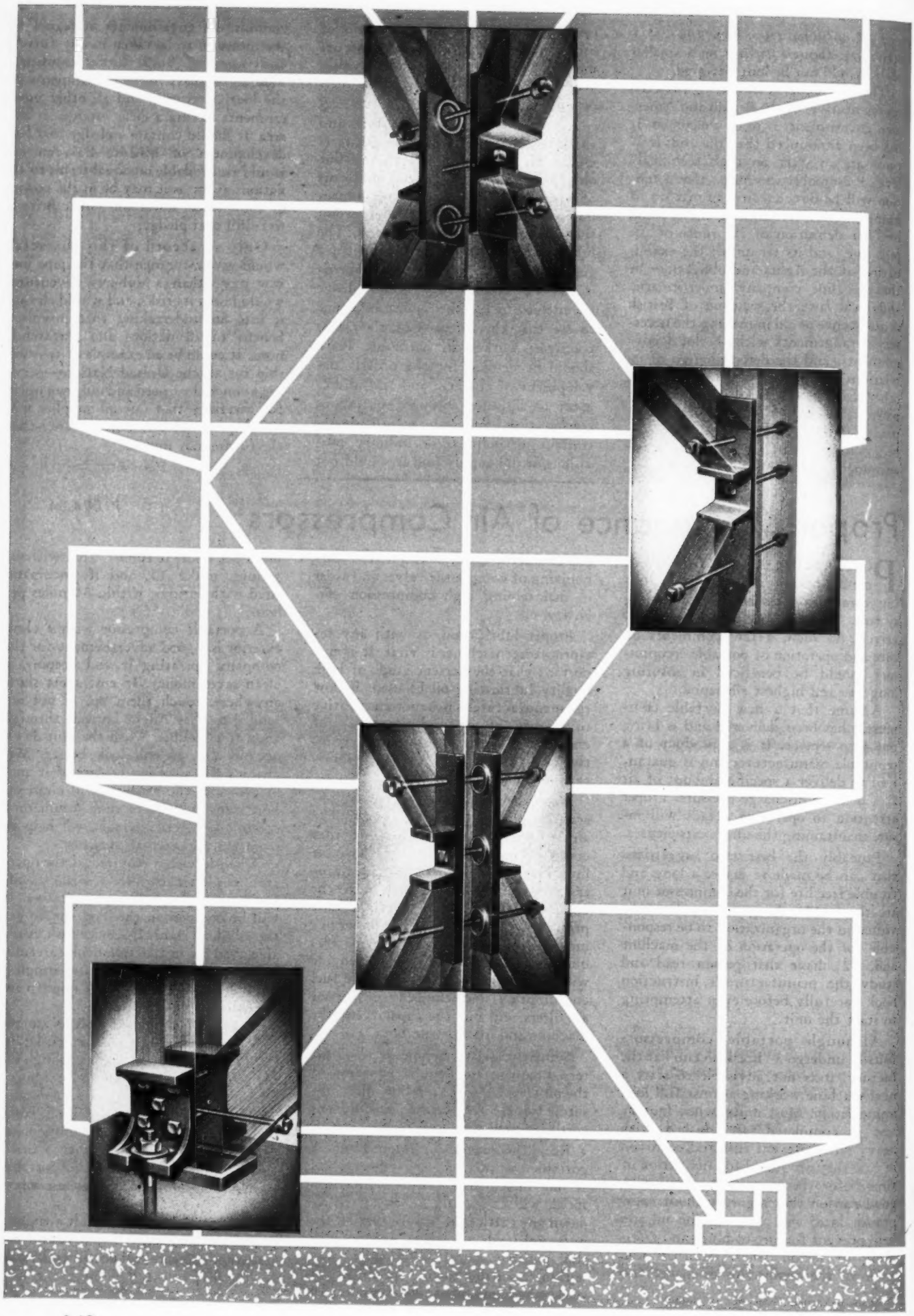
[1]Article by courtesy Compressed Air Institute.



THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 84

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their seventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue, 73-79, inclusive, in the January, 1944, issue, and 80-82, inclusive, in the April, 1944, issue.

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Torrington Company, Bantam Bearings Division	(sheet 2)	164	June	P 213.123.
Whitney Chain & Mfg. Co.	(sheet 2)	162	June	P 515.341.

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Complete range of carbon and alloy steels
Sizes: ½ in. to 8⅝ in. O.D.

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Carbon grades
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THE BABCOCK & WILCOX TUBE COMPANY

SEAMLESS TUBE DIVISION
BEAVER FALLS, PA.

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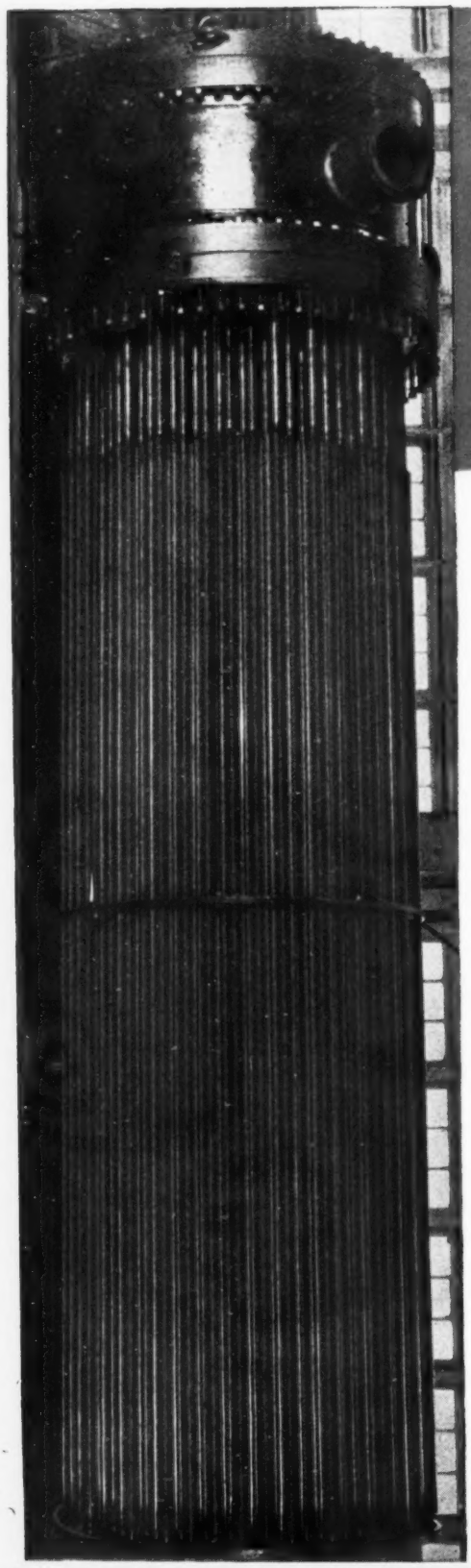
PHYSICAL CONSTANTS OF HYDROCARBONS

Hydrocarbon	Specific gravity 20/4 °C.	M. P. °C.	B. P. °C.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Spec. heat	Heat of vaporization Cal/G.	Heat of combustion K-Cal/mol.	Aniline point °C.	Coeff of expansion °C.	Critical constants P Atms.	Critical constants T °C.	Critical constants D	Vapor pressure °C.	Vapor pressure mm.	Octane number Actual	Octane number Blending	Surface tension 20°C. / Flash °C.
$C_{11}H_{24}$ Undecane	5.396 (air) / 0.74025	−25.62	195.8	1.41727	0.011717^{20} / 0.008641^{40}	0.524^{25}	58.5	1775.3p	80.6	0.0009678^{0-30}	19.9	369.4	0.228	75.2 / 126.6	11 / 100			
$C_{12}H_{26}$ Dodecane	5.86 (air) / 0.74876	−9.60	216.26	1.42156	0.013535^{25}	0.521^{25}	54.9	1932.4p	83.7	0.0009619^{0-30}	18.5	390.6	0.2255	92.0 / 169.5 / 190.0	10.1 / 224.0 / 437.0			/ 73.9
$C_{13}H_{28}$ Tridecane	0.7567	−6.2	236.5	1.4250^{25}	0.0242^{20} (S) / 0.010480	0.4896^{0-50}	51.5	2110.5	87.0 cst	0.0009166^{0-30}	17.5	410.0	0.2240	107.3 / 162.0	11 / 100			
$C_{14}H_{30}$ Tetradecane	6.8314 (air) / 0.7632	5.5	253.5	1.42886	0.021782^{20} / 0.012595^{50}	$0.523^{17.5}$	48.2	2271.0	89.5 cst	0.000893^{0-30}	16.56	427.8	0.2220	122.3 / 178.3	11 / 100			20.2100 / 100.0
$C_{15}H_{32}$ Pentadecane	0.7689	10.0	272.7	1.431^{25}	0.02812^{22}	0.4966^{0-50}	44.9	2415.4p	92.0 cst	0.0008573^{0-30}	15.75	444.4	0.2212	136.6 / 193.6	11 / 100			
$C_{16}H_{34}$ Hexadecane (Cetane)	0.77335	18.14	286.5	1.43435	0.035162^{20} / 0.018585^{50}	0.495^{0-50}	41.9	2556.1p	95.1	0.0008045^{0-30}	15.10	461.1	0.2205	150.0 / 208.1	11 / 100			27.66 / 110.0
$C_{17}H_{36}$ Heptadecane	0.7783	21.0	305.8	1.4360^{25}	0.04153^{30} (S) / 0.015690	0.6218	39.3	2743.2	98.0 cst		14.4	476.1	0.2195	162.9 / 221.8	11 / 100			24.175
$C_{18}H_{38}$ Octadecane	0.7822	28.0	317.9	1.4344^{32}	0.045292^{20} / 0.023445^{50}	0.6357	36.5	2903.2	100.0 cst		13.8	490.6	0.2186	174.9 / 234.9	11 / 100			27.5832
$C_{19}H_{40}$ Nonadecane	0.7857	31.4	336.2	1.4356			34.2	3021.8	102.0 cst		13.43	502.8	0.2203	186.4 / 248.0	11 / 100			
$C_{20}H_{42}$ Eicosane	0.7888	36.7	205.0^{15}	$1.434^{42.9}$		0.512^{6}		3183.1p	105.0 cst		13.6	500.0		198.0 / 223.4	11 / 30			
$C_{21}H_{44}$ Henicosane	0.7585^{70}	40.4	$172–172.5^{2.5}$	1.4240^{70}	0.0478^{50} (S) / 0.018311^{0}		45.0	3335.1	107.0 cst		12.4	527.7		209.0 / 235.0	11 / 30			
$C_{22}H_{46}$ Docosane	0.7782^{44}	45.7	230.0^{15}	1.4400		0.5590^{48-73}		3491.4	109.0 cst		12.1	538.9		220.0 / 246.0	11 / 30			
$C_{23}H_{48}$ Tricosane	0.7785^{47}	47.0	240.0^{15}	1.420^{90}				3693.6	112.0 cst		11.7	540.0		230.0 / 256.4	11 / 30			
$C_{24}H_{50}$ Tetracosane	0.7682^{70}	49.4	250.0^{15}	1.4288^{70}				3863.3	114.0 cst		12.0	561.5		240 / 267	11 / 30			
$C_{25}H_{52}$ Pentacosane	0.7785^{60}	53.3	259.0^{15}	1.4380^{60}		$0.521^{21.5}$		3941.5p	116.0 cst		11.1	572.1		250 / 277	11 / 30			

See table P 771.001. B for footnotes.

Table from "Physical Constants of the Principal Hydrocarbons," 4th edition, by courtesy of copyright owner, The Texas Company.



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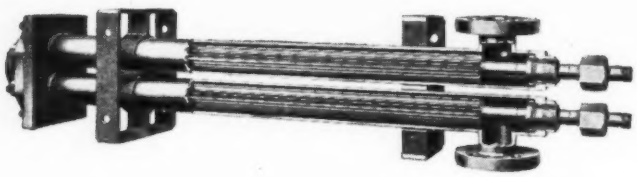

G-FIN . . . the pioneer finned-tube heat transfer surface with longitudinal fins . . . has PROVED its effective principle and also its superior construction in many tens of thousands of installed units, some of which have been in service for well over 10 years.

The illustrations in this advertisement show two of the many different types of heat transfer apparatus in which this patented surface has proved highly successful. The illustration at the left is one of more than 100 large G-Fin bundles used in Stratco Contactors in alkylation plants. The small illustration above shows the design of the Twin G-Fin Section, of which more than 40,000 are in use on a wider variety of services than any other design of heat transfer apparatus.

G-Fin elements are also applicable to vacuum or pressure condensers, baffled exchangers, preheaters, storage tank oil heaters and other types of exchangers. Before buying your next heat transfer apparatus, be sure to investigate the possibilities of a G-Fin unit.

WRITE FOR BULLETIN 1625

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285 MADISON AVENUE, NEW YOR 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

HEAT TRANSMISSION THROUGH FURNACE WALLS

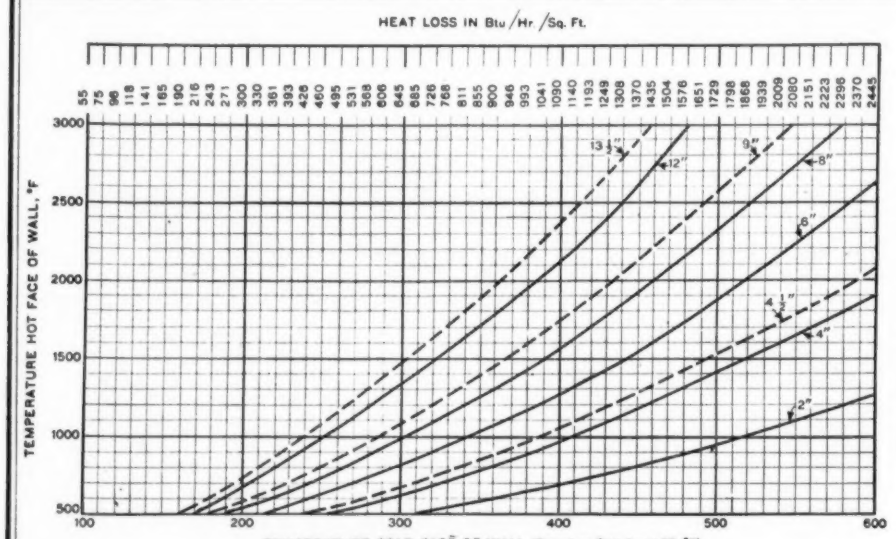


Fig. 5. Wall of one component, K = 7.5

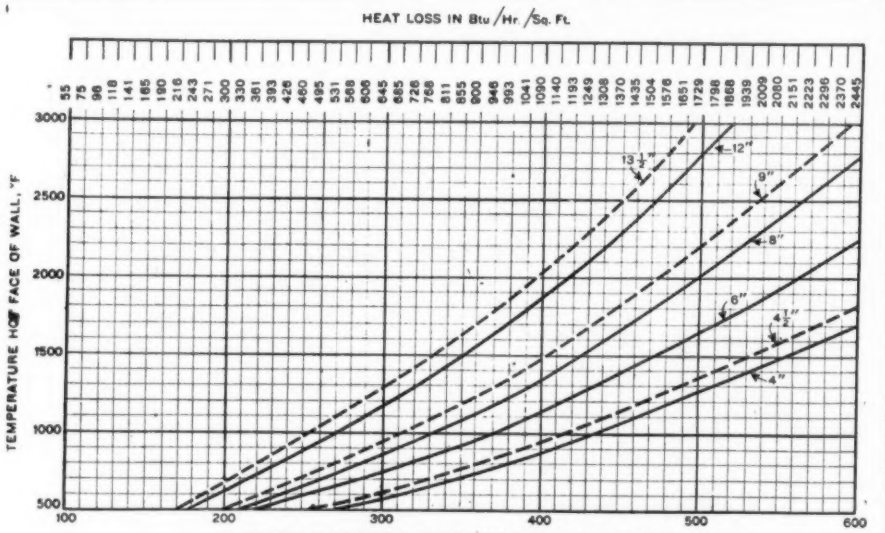


Fig. 6. Wall of one component, K = 9.0

DIRECTIONS FOR USE OF CHART

Fig. 5 and Fig. 6 are one-component wall charts. Select chart corresponding to the known K-factor. Find the known hot-face temperature on the left hand vertical scale and move across the chart to the given wall thickness. The cold-face temperature may be read directly from the lower scale and heat loss in B.t.u. per hr. per sq. ft. on the upper scale.

The curves in the charts are plotted in terms of conductivity factors (K) in order to make them adaptable to any of the materials commonly used in the construction of most industrial furnaces. This arrangement also permits the use of more accurate conductivity data that may later be developed for specific materials.

The dashed line curves on the chart are for standard thickness of brick walls. Solid curves may be used for selection of proper wall thicknesses when materials such as refractory concrete are used and the designer is not limited by standard size units.

Fig. 7 is a two-component wall chart with the thickness and K-value shown. To obtain temperature on the hot face of insulation multiply heat loss by 1.2 and subtract from temperature of hot face of wall. Select chart corresponding to K-factor and thickness of refractory on hot-face of wall. Each curve applies to this refractory wall with the indicated insulating sections on the cold side. Read directly cold-face temperature (below) and heat loss (above). In most cases a choice of insulating materials is indicated. For any one curve K/L for the several insulating materials is the same. Joint temperature should be determined in order to avoid use of an insulating material above its temperature range.

This series of tables by courtesy of copyright owner, The Atlas Lumnite Cement Company.

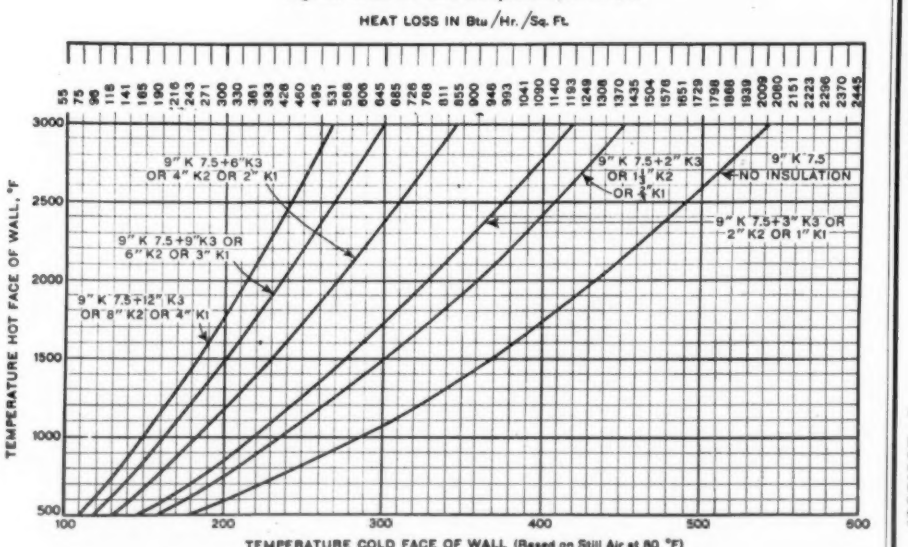
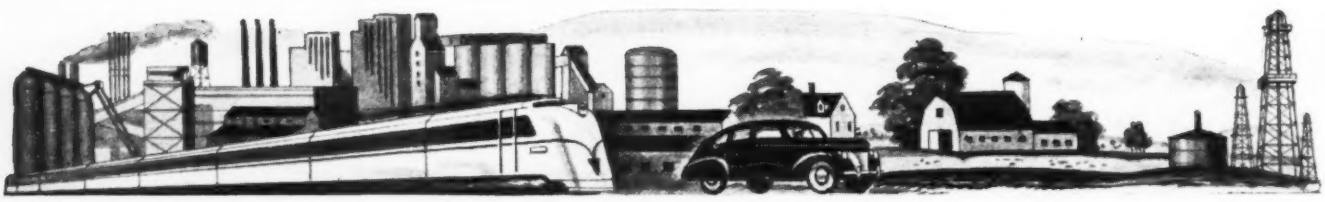

HEAT LOSS IN Btu /Hr. /Sq. Ft.
TEMPERATURE HOT FACE OF WALL, °F
TEMPERATURE COLD FACE OF WALL (Based on Still Air at 80 °F)
9" K 7.5+6"K3 OR 4" K2 OR 2" K1
9" K 7.5+9"K3 OR 6" K2 OR 3" K1
9" K 7.5+12" K3 OR 8" K2 OR 4" K1
9" K 7.5+2" K3 OR 1½" K2 OR 2"K1
9" K 7.5 NO INSULATION
9" K 7.5+3" K3 OR 2" K2 OR 1" K1

Fig. 7. Wall of two components, thickness and K-values as shown

On the Far-Flung Battle Fronts

of the world, millions of Hyatt Roller Bearings are doing their jobs consistently well...carrying the bearing loads of tanks, planes, guns, ships, trucks, and tractor bulldozers.

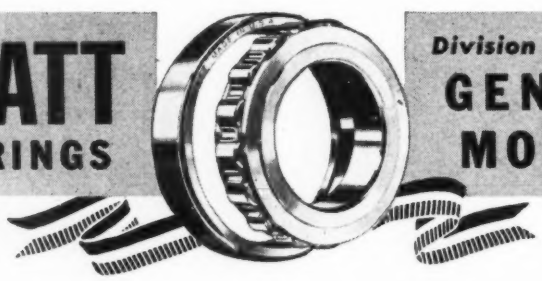
On the Home Front, too,



Hyatt continues to serve America...on railway and highway and farm, in mill and factory... wherever wheels and shafts turn for victory!

Hyatt Roller Bearings are built to last...with minimum care. But don't forget to give them the proper attention all precious anti-friction bearings deserve today.

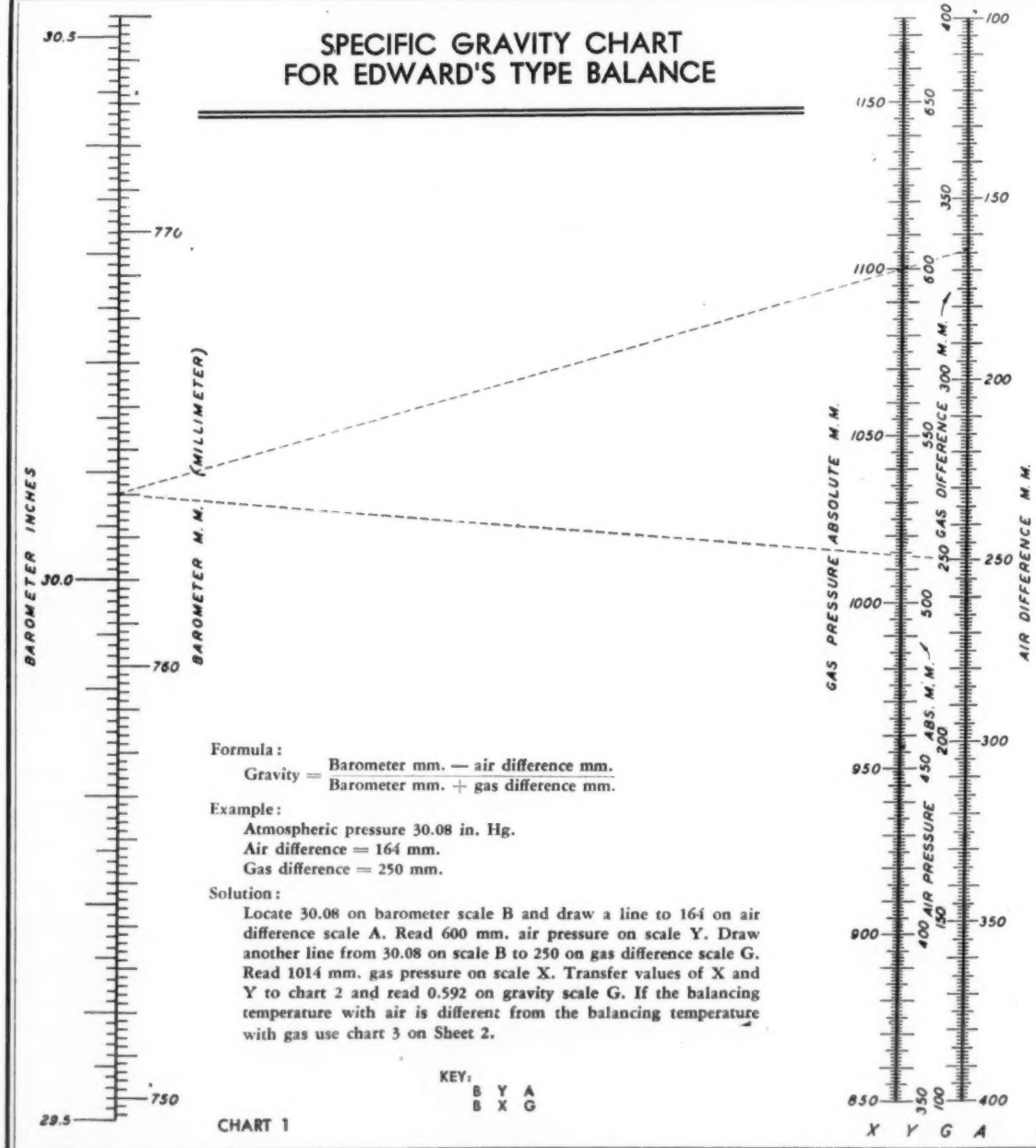
HYATT BEARINGS



Division of GENERAL MOTORS

HYATT BEARINGS DIVISION · GENERAL MOTORS CORPORATION · HARRISON, NEW JERSEY

SPECIFIC GRAVITY CHART FOR EDWARD'S TYPE BALANCE



Formula:

$$\text{Gravity} = \frac{\text{Barometer mm.} - \text{air difference mm.}}{\text{Barometer mm.} + \text{gas difference mm.}}$$

Example:

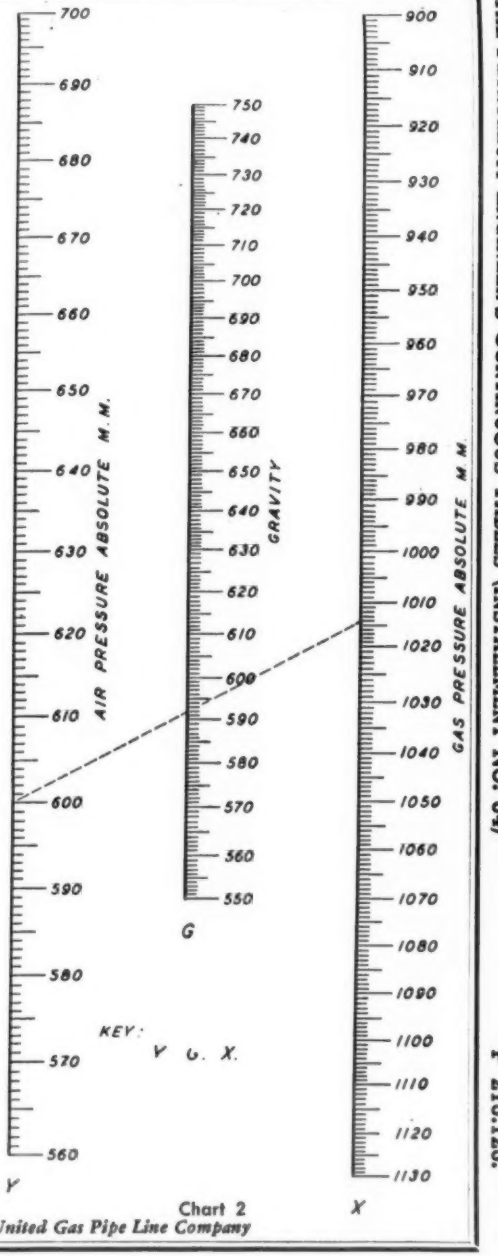
Atmospheric pressure 30.08 in. Hg.
Air difference = 164 mm.
Gas difference = 250 mm.

Solution:

Locate 30.08 on barometer scale B and draw a line to 164 on air difference scale A. Read 600 mm. air pressure on scale Y. Draw another line from 30.08 on scale B to 250 on gas difference scale G. Read 1014 mm. gas pressure on scale X. Transfer values of X and Y to chart 2 and read 0.592 on gravity scale G. If the balancing temperature with air is different from the balancing temperature with gas use chart 3 on Sheet 2.

KEY:
B Y A
B X G

CHART 1



KEY:
Y G. X.

Chart 2

Charts by W. D. Parkes, United Gas Pipe Line Company

You wouldn't put a diving suit on a *POLE VAULTER*

LAY·SET *Preformed* IS LIMBER

• Putting non-preformed wire rope on your machines is like expecting a pole vaulter to make a record when dressed in a diving suit. You shouldn't expect a wire rope that is twisted tightly and under constant tension to operate well and long.

In Hazard LAY-SET Preformed every wire and strand is preshaped at the mill to the exact helix it must assume in the finished rope. That's why **LAY-SET** is at ease, relaxed, more flexible, and perfectly willing to work. Being free of torsional stresses and strains, being unhampered by twisted effort, Hazard **LAY-SET** Preformed lasts longer, gives you greater dollar value. Be sure your next rope is Hazard **LAY-SET** Preformed.

Hazard **LAY-SET** Preformed Wire Rope is "in the service" on countless jobs for the Armed Forces where it is proving its many advantages. Specify it for *your* use.

HAZARD WIRE ROPE DIVISION • Wilkes-Barre, Pa., Chicago, Pittsburgh, Fort Worth, Houston, Wichita, San Francisco, Denver, Los Angeles • *Distributors in all important oil field centers*
AMERICAN CHAIN & CABLE COMPANY, INC. • BRIDGEPORT, CONNECTICUT

HAZARD LAY·SET *Preformed* ROTARY® LINES

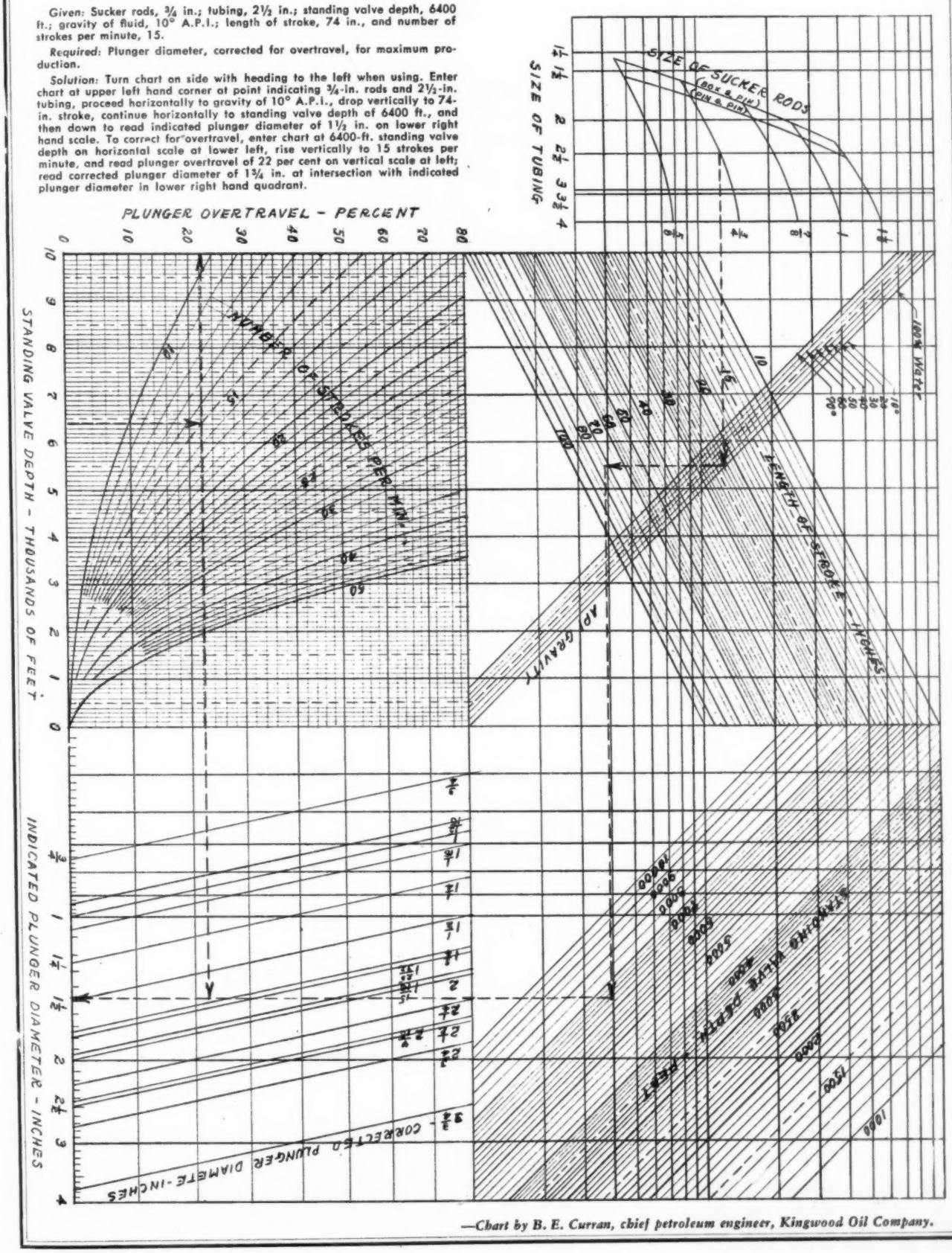
PLUNGER DIAMETER FOR MAXIMUM PRODUCTION

EXAMPLE

Given: Sucker rods, ¾ in.; tubing, 2½ in.; standing valve depth, 6400 ft.; gravity of fluid, 10° A.P.I.; length of stroke, 74 in., and number of strokes per minute, 15.

Required: Plunger diameter, corrected for overtravel, for maximum production.

Solution: Turn chart on side with heading to the left when using. Enter chart at upper left hand corner at point indicating ¾-in. rods and 2½-in. tubing, proceed horizontally to gravity of 10° A.P.I., drop vertically to 74-in. stroke, continue horizontally to standing valve depth of 6400 ft., and then down to read indicated plunger diameter of 1½ in. on lower right hand scale. To correct for overtravel, enter chart at 6400-ft. standing valve depth on horizontal scale at lower left, rise vertically to 15 strokes per minute, and read plunger overtravel of 22 per cent on vertical scale at left; read corrected plunger diameter of 1¾ in. at intersection with indicated plunger diameter in lower right hand quadrant.


PLUNGER OVERTRAVEL - PERCENT
0 10 20 30 40 50 60 70 80
STANDING VALVE DEPTH - THOUSANDS OF FEET
0 1 2 3 4 5 6 7 8 9 10
NUMBER OF STROKES PER MIN.
SIZE OF TUBING
1¼ 2 2½ 3½
SIZE OF SUCKER RODS
(BOX & PIN)
(PIN & PIN)
⅝ ¾ ⅞ 1
100% WATER
10° API GRAVITY
LENGTH OF STROKE - INCHES
STROKING VALVE DEPTH - FEET
INDICATED PLUNGER DIAMETER - INCHES
CORRECTED PLUNGER DIAMETER - INCHES

—Chart by B. E. Curran, chief petroleum engineer, Kingwood Oil Company.

This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request.

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

Saves floor space.

Desired delivery temperature Automatically maintained.

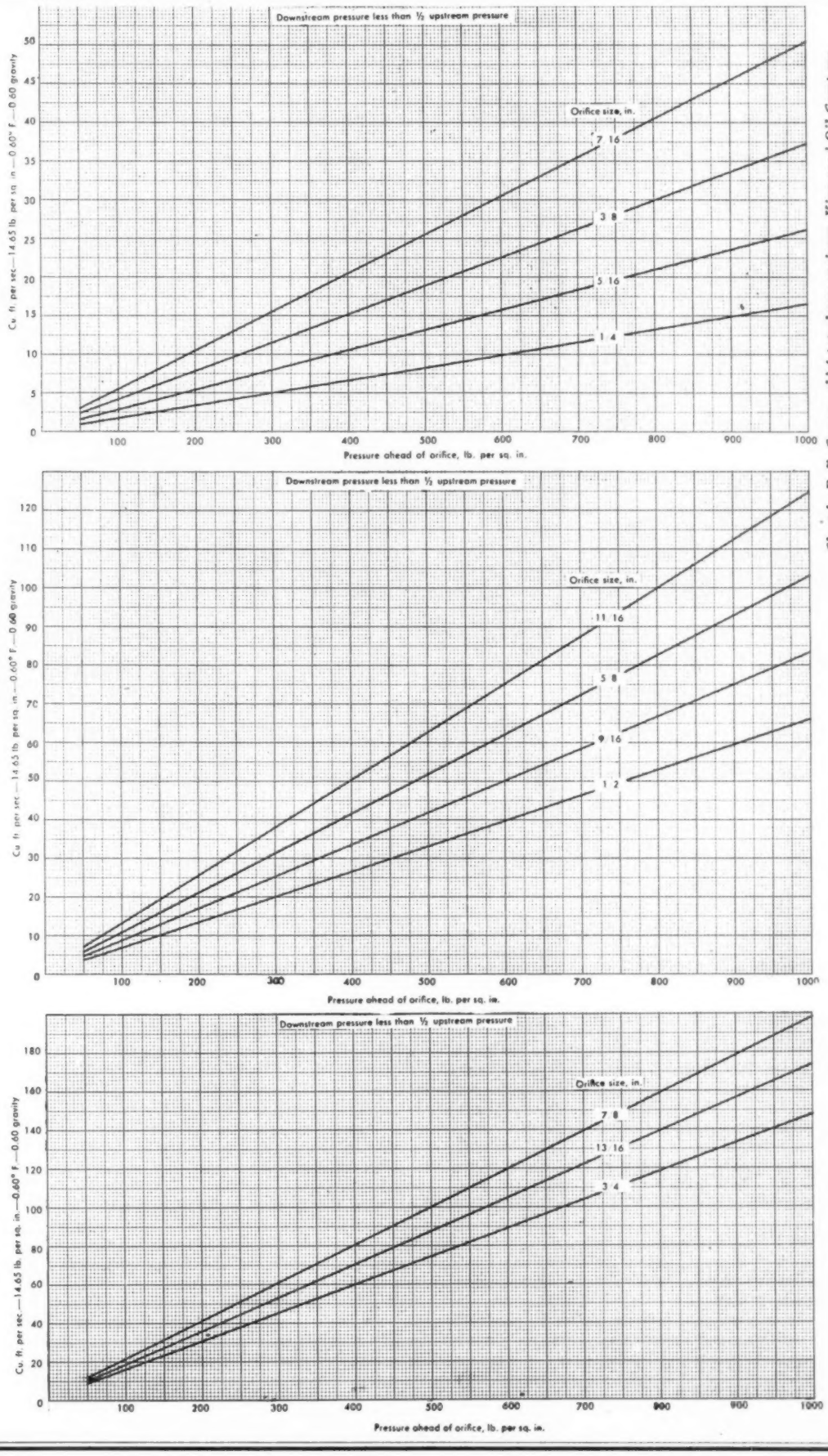
Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

278 WILSON, SO. NORWALK, CONN.

GAS FLOW THROUGH ORIFICES


Downstream pressure less than ½ upstream pressure
Orifice size, in.
7 16
3 8
5 16
1 4
Cu. ft. per sec.—14.65 lb. per sq. in.—0.60° F.—0.60 gravity
Pressure ahead of orifice, lb. per sq. in.
Downstream pressure less than ½ upstream pressure
Orifice size, in.
11 16
5 8
9 16
1 2
Cu. ft. per sec.—14.65 lb. per sq. in.—0.60° F.—0.60 gravity
Pressure ahead of orifice, lb. per sq. in.
Downstream pressure less than ½ upstream pressure
Orifice size, in.
7 8
13 16
3 4
Cu. ft. per sec.—14.65 lb. per sq. in.—0.60° F.—0.60 gravity
Pressure ahead of orifice, lb. per sq. in.

—Chart by B. E. Curran, chief petroleum engineer, Kingwood Oil Company.

"Here's why I specify

WHITNEY CHAIN DRIVES"

"Counting on past performance, I know when I get a Whitney Chain, I'm getting a rugged built chain that'll give me plenty of service.

"And there's another kind of service I can count on when I buy Whitney Chains. It's the oil field's top-notch distributor service that's ready to see that I get the stuff I need, *when I need it!*"

You'll find Whitney's alloy-armored steels build extra performance into Whitney Chains. A proven stamina that stands the toughest going . . . takes shocks and overloads . . . and keeps delivering full power to the job.

And you can depend on Continental or Republic for on-the-spot service — whether it's equipment you need or engineering help. The Whitney Chain & Mfg. Co., Hartford 2, Conn.

It pays to specify

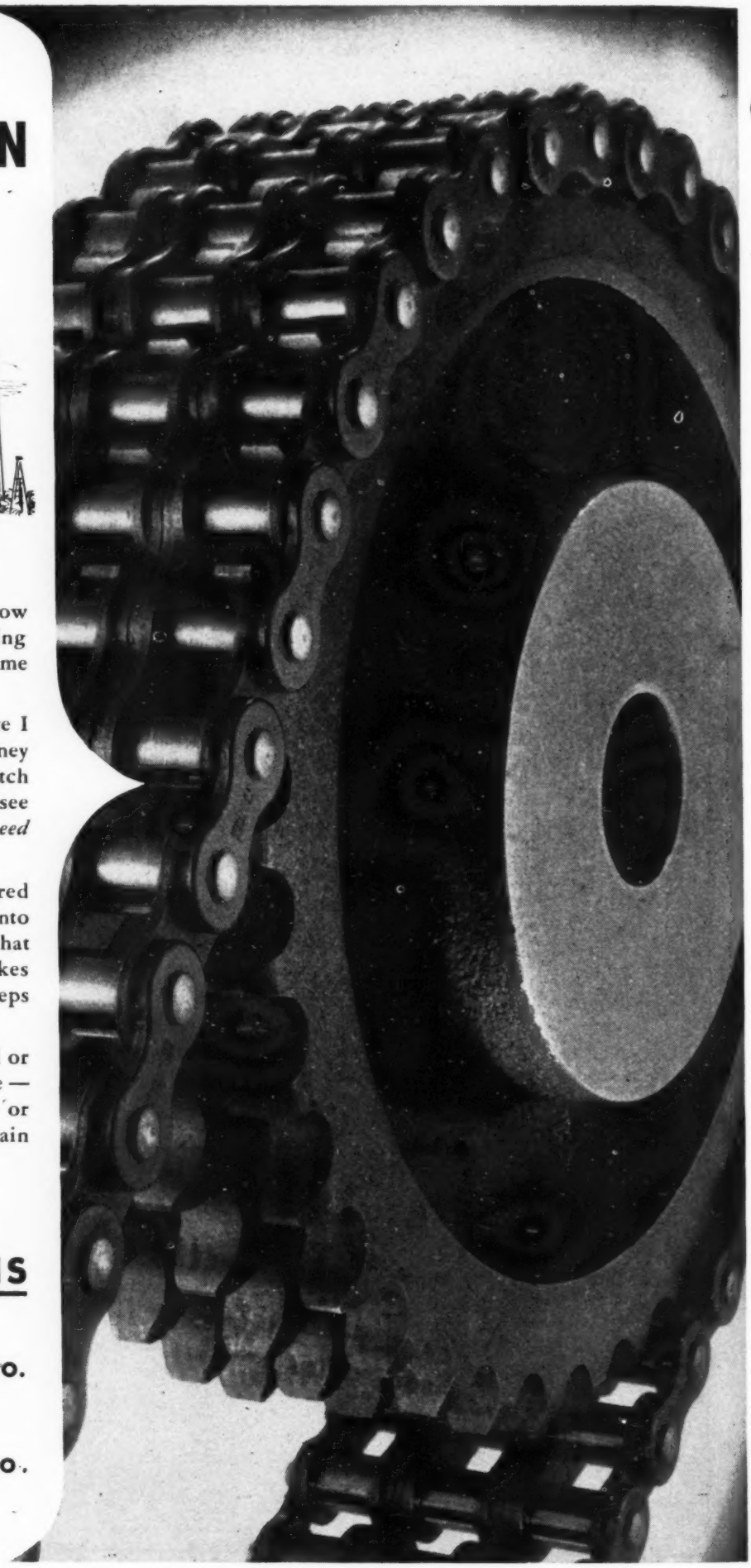
WHITNEY CHAINS

Distributed by

THE CONTINENTAL SUPPLY CO.
DALLAS, TEXAS

and

THE REPUBLIC SUPPLY CO. OF CALIFORNIA
LOS ANGELES, CAL.



SPECIFIC GRAVITY CHART FOR EDWARDS TYPE BALANCE

Where:
T_1 = gas temperature °F. abs., and
T_2 = air temperature °F. abs.
G = gravity,
G^1 = gravity when balancing temperatures are not equal,

Equation: $G = G^1 \frac{T_1}{T_2}$

Example: The balancing temperature with air is 60° F. and the balancing temperature with gas is 62° F., indicated gravity is 0.586.

Solution: Locate 62° F. on scale T_1. Connect to 60° F. on scale T_2. From intersection of this line on turning scale X. Draw another line to 0.586 on scale G_1. Read 0.588 correct gravity on scale G.

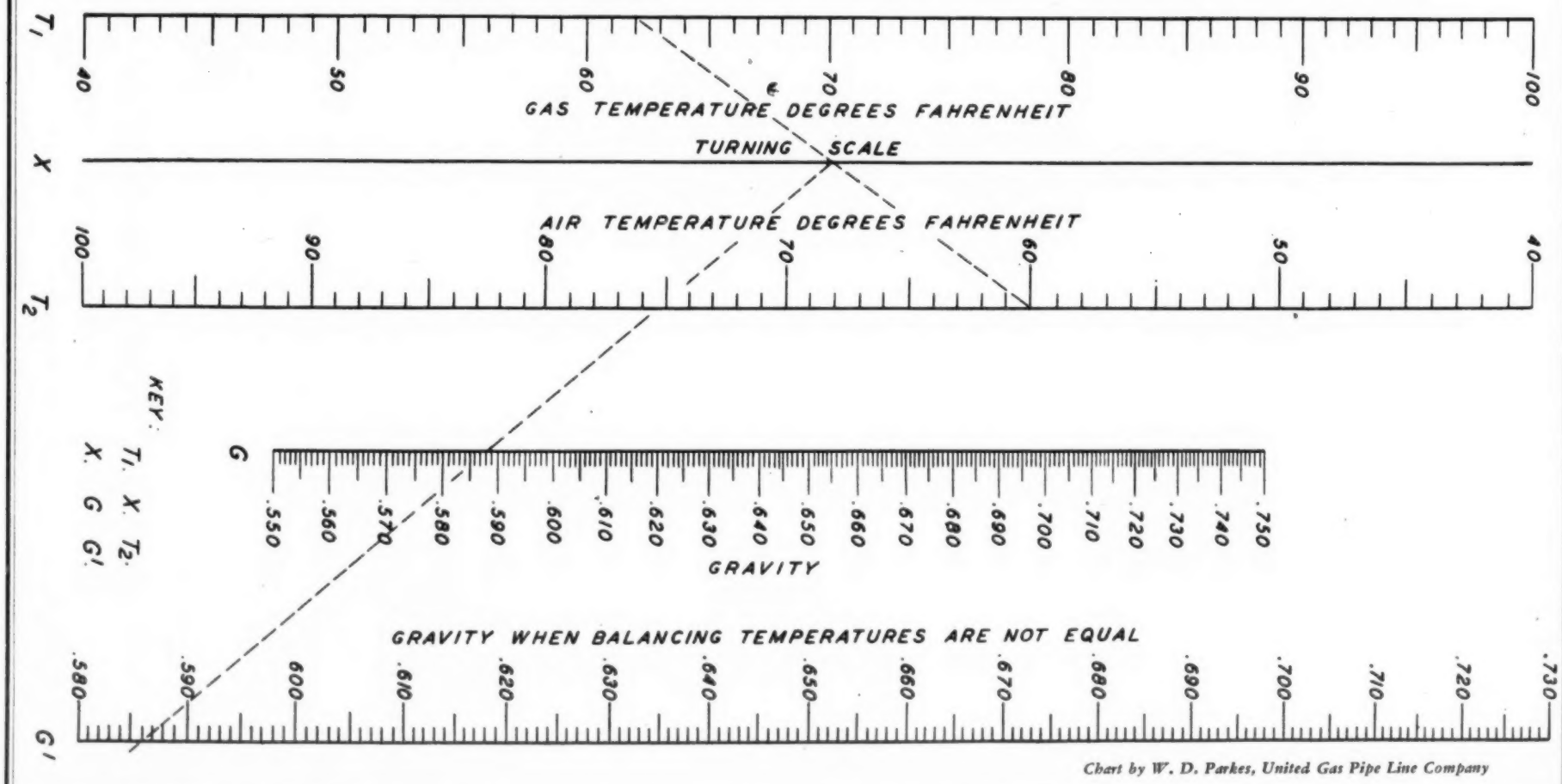
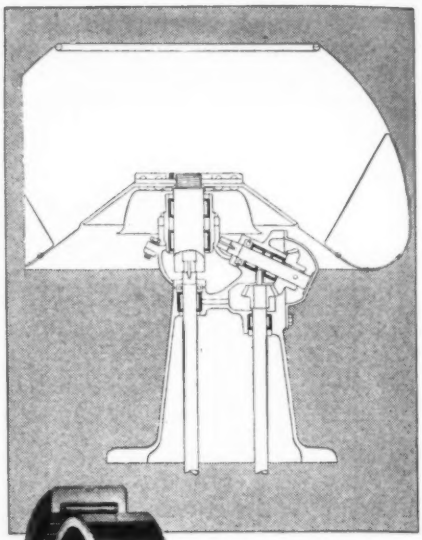


Chart by W. D. Parkes, United Gas Pipe Line Company

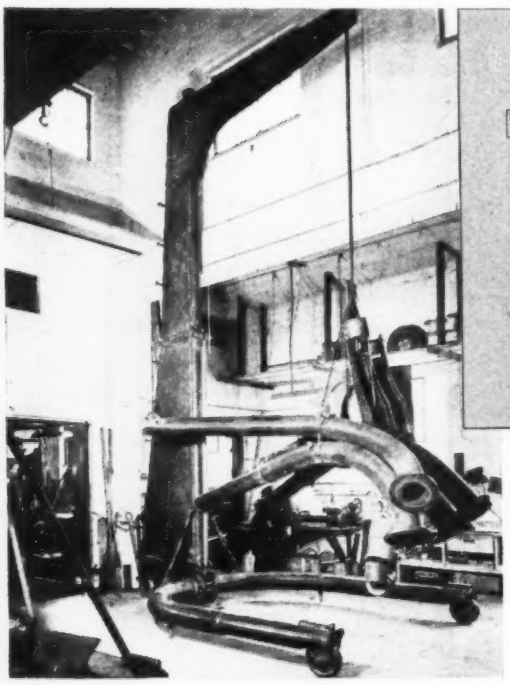
THE PETROLEUM ENGINEER'S CONTINUOUS TABLES (INSTALLMENT No. 84)
Sheet 2
P 213.123.

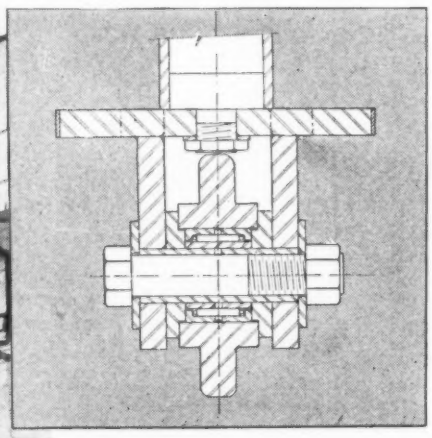
IN THE NEWS
WITH TORRINGTON BEARINGS

A 95-FOOT "STRETCH" is available through this Hi-Reach Platform Telescoper, product of the Economy Engineering Company, used for plane and hangar maintenance by our Army Air Forces. Torrington Type DC Needle Bearings were supplied for the twenty-two hoist mechanism sprocket shafts. These bearings were selected because of their compact design features coupled with extremely high capacity, permitting light but strong construction in the telescoping mechanism.

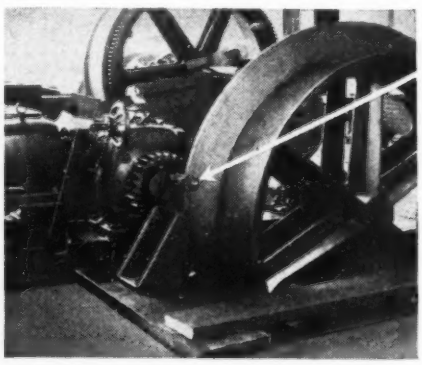


THE DRY CLEANING BUSINESS is at an all-time peak and equipment is being subjected to severe performance tests. Cross-section shows the application of Torrington NCS Needle Bearings in the pedestal assembly of a dry cleaning unit manufactured by Columbia Appliance Corporation. Now operating almost continuously day after day, these compact anti-friction bearings are demonstrating the advantages of their high capacity and long service life under heavy load conditions.





THIS PORTABLE HYDRAULIC HOIST, manufactured by Federal Aircraft Works primarily for aircraft engines, handles other heavy parts with equal facility. Cross-section shows installation of Torrington Type NCS Needle Bearing in the hydraulic ram sprocket, where it is subject to extremely heavy loads. Its low coefficient of friction is an important factor in contributing to smooth, anti-friction operation.



CAM FOLLOWERS have proven to be an interesting application of Torrington Type RC Needle Bearings in the wire manufacturing machinery of New England Butt Company. They are used to impart a "wobble" motion to the loose fitting ring on the drum of the capstan, the ring guiding the wire so that it "lays" correctly on the drum which revolves at a maximum speed of 125 feet per minute. The high capacity and elimination of stress concentrations of these heavy duty Type RC Torrington Needle Bearings make them ideal for this purpose.

TORRINGTON-BANTAM ENGINEERS, with long experience in the design and manufacture of anti-friction bearings of every major type—tapered roller, straight roller, needle and ball—are in an unusual position to give expert assistance in the design and selection of the correct bearings for any given application. For assistance with today's or tomorrow's bearing problems, TURN TO TORRINGTON.

ARMY E NAVY

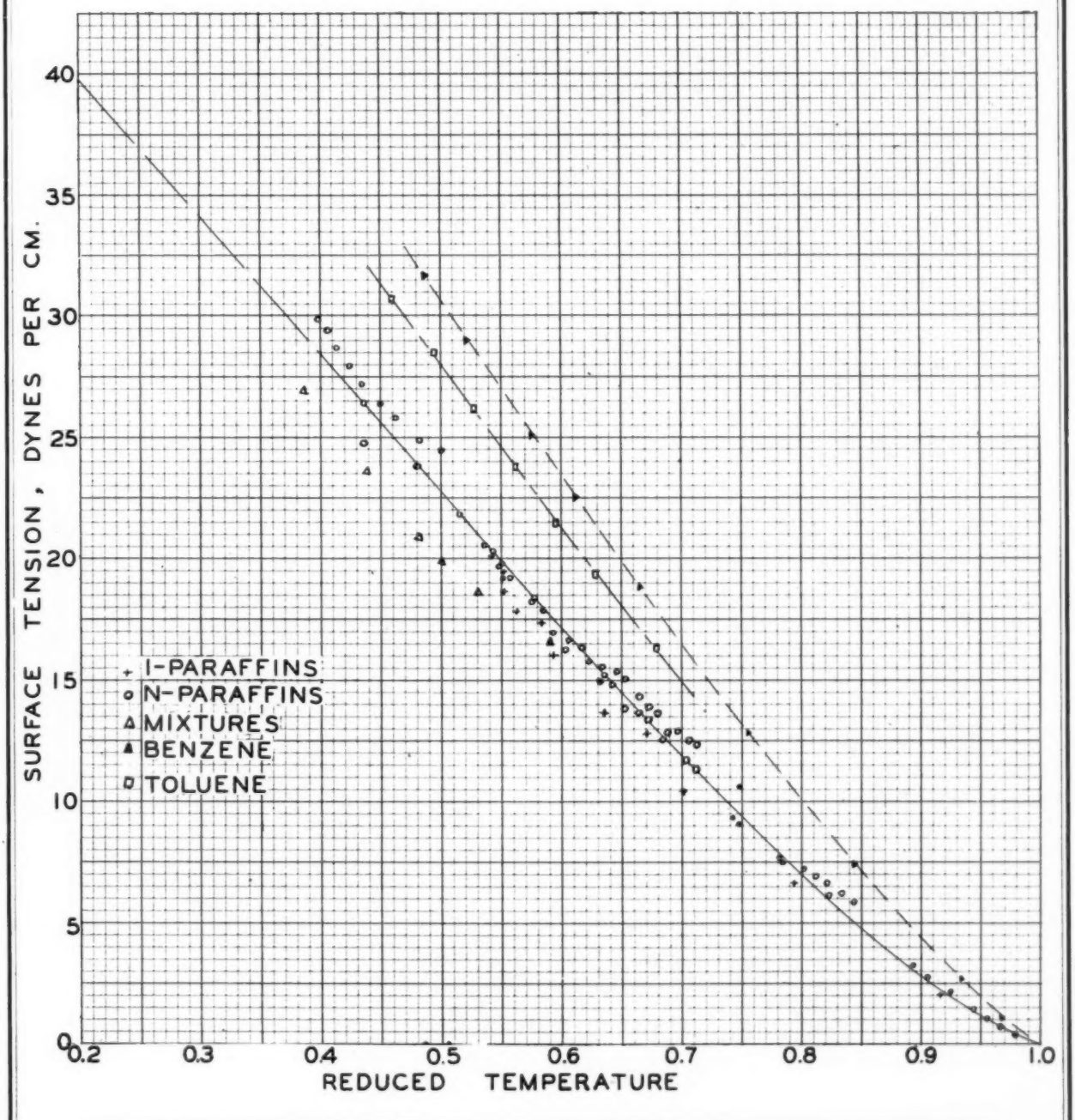
TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

SURFACE TENSION AS A FUNCTION OF REDUCED TEMPERATURE



—Chart by George Granger Brown, University of Michigan.

Which type of Exchanger to use?

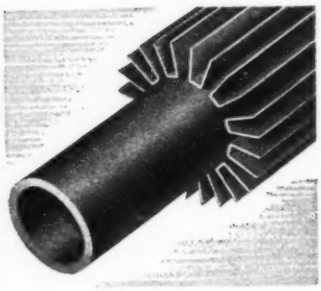
You can't go wrong with BROWN FINTUBE *Sectional* EXCHANGERS

● **FOR INSTANCE:** — if the capacity requirement should be changed, you don't have to scrap a lot of expensive, and practically new equipment — Simply add a few sections. It's easy and inexpensive.

If the duty changes, you can take out the original "hair-pins", and substitute hair-pins having more fins, or those made with Brown "cut and twisted" fintubes, that produce greater turbulency of the "shell-side" commodity, increasing the thermal efficiencies from 25% to 50% under certain conditions.

OPERATING AND MAINTENANCE ADVANTAGES: — The new gasketed head seal avoids lap, gland or ground joints, assuring positive gas-tight closure, time after time, with only a standard wrench — avoids torsional twisting,— and permits side by side mounting of the sections in minimum space. The patented "non-removable" rear end assembly simplifies inspection and maintenance. There's nothing to lower to the ground, and lift back again. And Brown's exclusive resistance-welded integrally-bonded fintube construction insures trouble-free operation during the entire life of the tube.

But send for Bulletin No. 432. It gives full details about Brown Fintube Sectional Heat Exchangers, dimensions of standard units, and contains other data of much interest to engineers and operating men.



Brown Integrally-Bonded Fintubes are used in all Brown Fintube Heat Exchangers,— are available in Exchangers made by most other manufacturers,— and are ideally suited for many other heating and cooling services. Furnished in plain, "longitudinal," or "cut and twisted" types,— wide range of sizes in low carbon or special steels. Design assistance furnished gladly.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

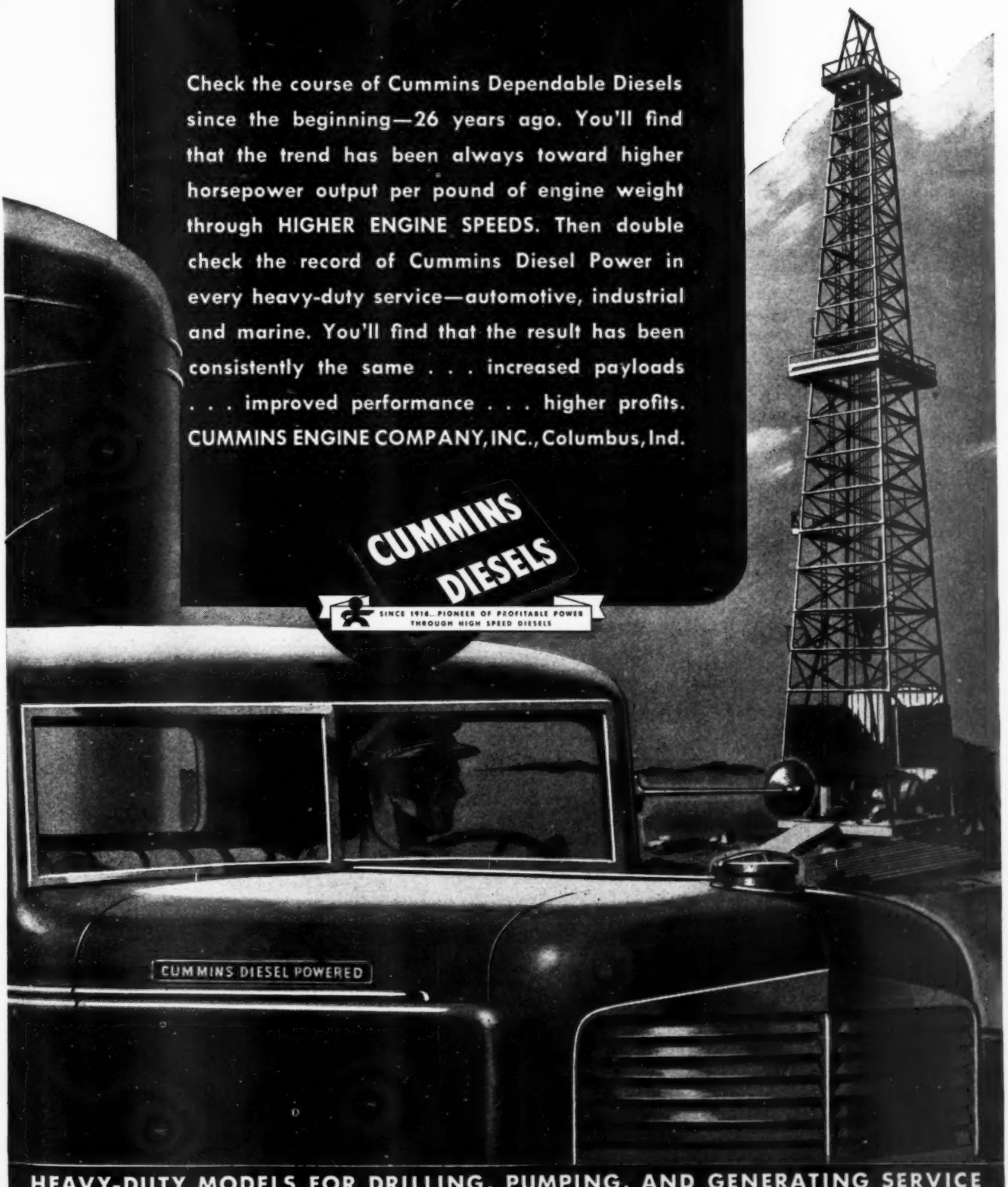
MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

CHECK AND DOUBLE CHECK

Check the course of Cummins Dependable Diesels since the beginning—26 years ago. You'll find that the trend has been always toward higher horsepower output per pound of engine weight through HIGHER ENGINE SPEEDS. Then double check the record of Cummins Diesel Power in every heavy-duty service—automotive, industrial and marine. You'll find that the result has been consistently the same . . . increased payloads . . . improved performance . . . higher profits. CUMMINS ENGINE COMPANY, INC., Columbus, Ind.

CUMMINS DIESELS

SINCE 1918... PIONEER OF PROFITABLE POWER THROUGH HIGH SPEED DIESELS



HEAVY-DUTY MODELS FOR DRILLING, PUMPING, AND GENERATING SERVICE

The "Traffic Cop" of the Gas Line

PETROLEUM ENGINEER Exclusive Feature

☆ A graphic pressure chart that keeps dispatchers on their toes

by L. E. Adler
Communications Engineer,
Magnolia Petroleum Company

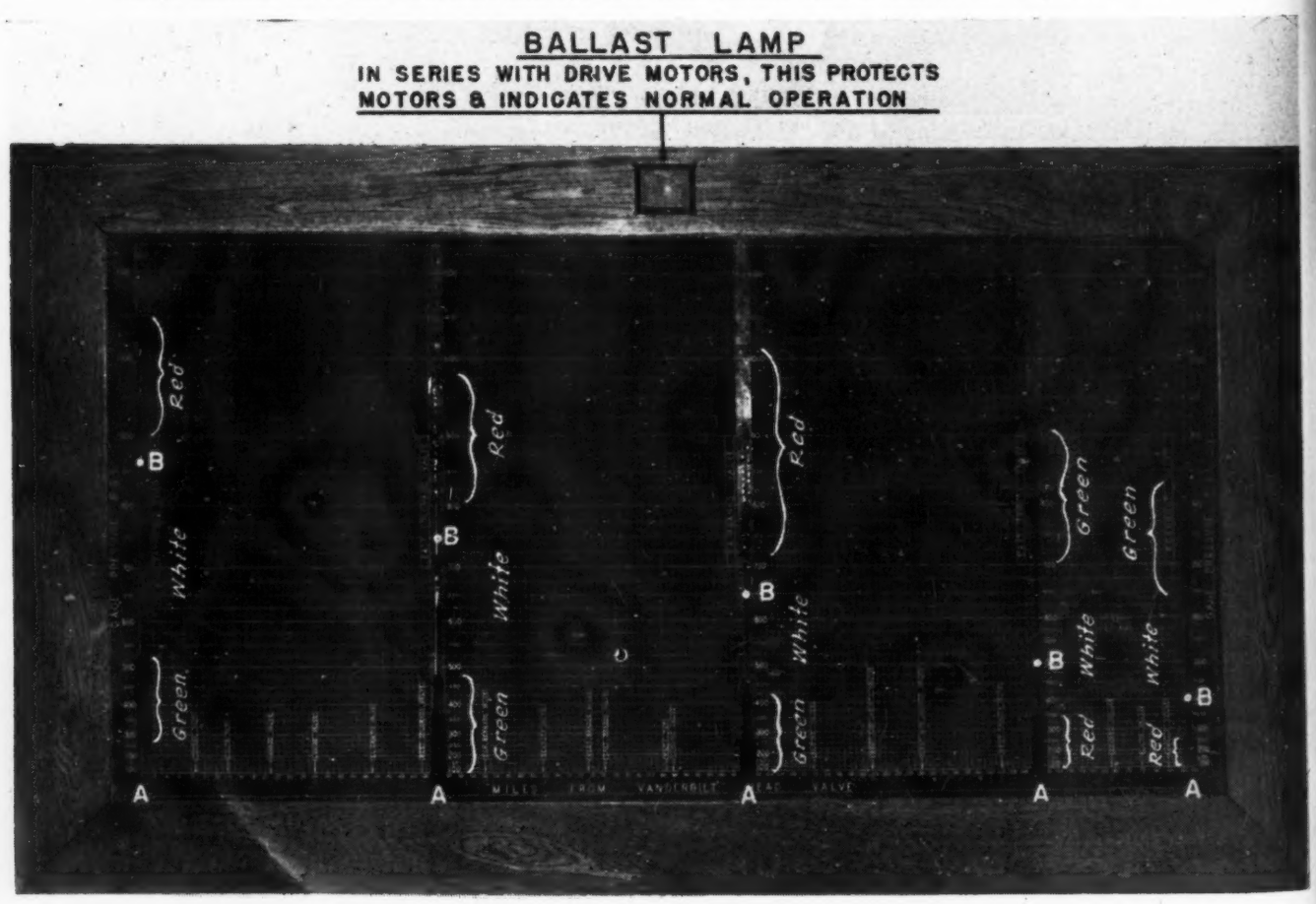
APPROXIMATELY three years ago, the Magnolia Petroleum Company constructed a telescopic gas line extending from its Jackson County properties to the Magnolia refinery at Beaumont, a distance of 200 miles. The pipe line was designed for high pressure transmission without assistance of compressor stations, the well pressures in the gas fields being high enough to successfully carry the gas its entire length.

The original purpose in designing the line was to eliminate unnecessary steel in the pipe sizes as the pressure decreased toward the point of delivery. The line is constructed from five different weights and two sizes of pipe, all of which vary in internal diameter and wall thickness. A constant watch, therefore, must be kept on the pressures so as not to exceed the safety factor established for the line. The fact that the line receives its initial pressure at Vanderbilt and does not have compressor stations, requires constant supervision by the dispatchers.

There is a time lag of approximately six hours from the initial supply at Vanderbilt before the gas reaches Beaumont and, due to the wartime conditions at the refinery, the operation fluctuates considerably over a period of time. If the refinery is using gas at a high delivery rate and then suddenly cuts off a large portion of its load and the initial point is reduced promptly at the same time, there is a 6-hr. supply on its way to Beaumont already in the line that must be handled. Sometimes this causes the pressure to rise considerably at the delivery end of the line. The fluctuating rate of flow, plus the fact that wartime conditions have required the use of inexperienced dispatchers, made it necessary that the operation of the line from a dispatching standpoint be made as near foolproof as possible.

On the dispatcher's chart, the wall thickness and pipe sizes are described in steps running east from Vanderbilt. Ob-

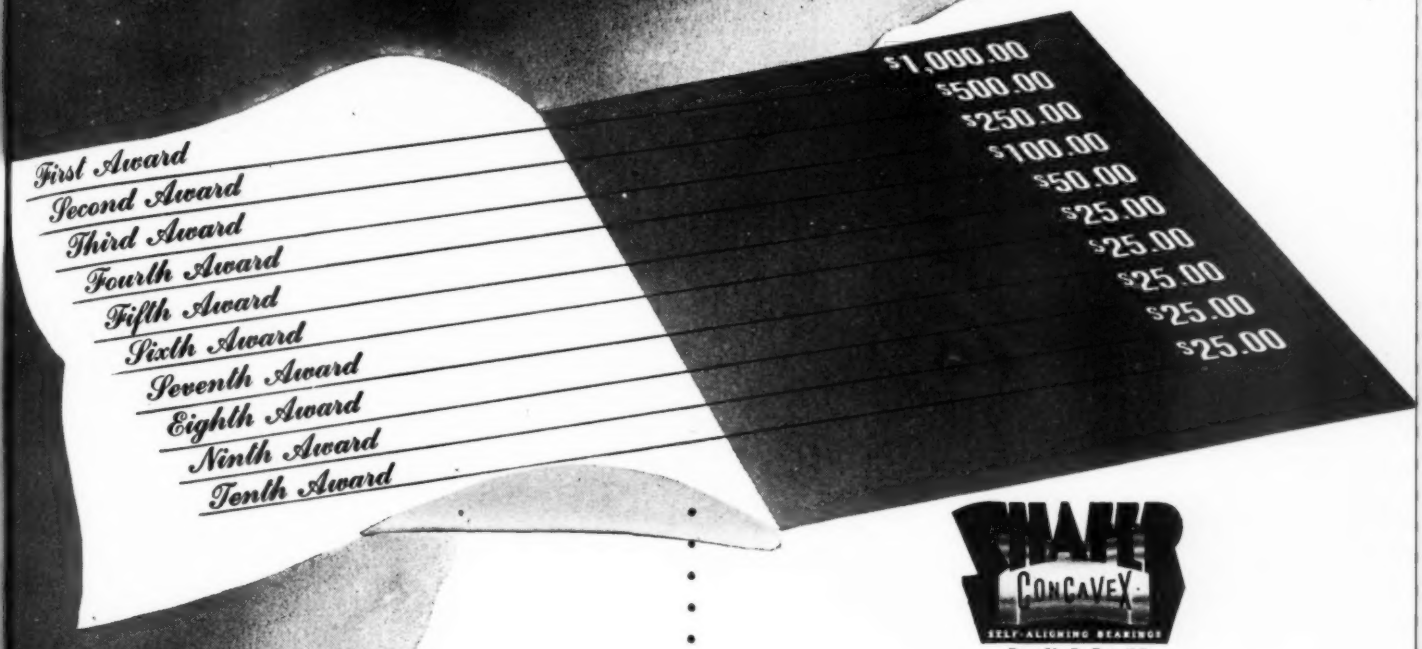
Fig. 1. Front view of graphic pressure chart. "A" slots represent the five key pressure points. "B" indicates miniature lamps mounted on vertical travelers and operated from remote control cabinet on dispatcher's desk



WHY THE

Shafer Achievement Awards

HAVE BEEN INSTITUTED



SHAFER CONCAVEX SELF-ALIGNING BEARINGS

Reg. U. S. Pat. Off.

We of Shafer believe our product is superior for the machines for which it is offered. The principle upon which Shafer Concavex Self-Aligning Roller Bearings are designed appears to meet the theoretical considerations that apply, as well as practical tests, to a greater extent than bearings not using this principle.

Nevertheless, we are constantly seeking out refinements in design, methods of manufacture, application or use that will result in even smoother performance, longer life, or improvements in design in the machines and equipment these bearings serve.

In view of the tremendous technological progress made during the war and the additional thousands of outside engineers and technicians who have become familiar with Shafer Bearings, we believe new uses may have been found for Shafer Bearings, or ideas for their improvement which we hope will thus be brought to our attention.

It is evident that bearing quality and performance will count heavily in the days ahead, because of the reductions in machine costs, the greater machine productive capacity, the gains in the welfare of the nation that can accrue from better machine performance. And certainly any men responsible for improvements in bearing use and manufacture may well merit the nation's recognition.

All suggestions and ideas will be judged by the following authorities:

JOHN J. SCHOMMER, Professor of Industrial Chemistry, Illinois Institute of Technology. Nationally recognized authority on industrial processes and engineering design.

PHILLIP C. HUNTLEY, Formerly Head of Mechanical Engineering Department, now Head of Civil Engineering Department, Illinois Institute of Technology. Widely known engineering consultant.

CHARLES A. NASH, Associate Professor Electrical Engineering, Illinois Institute of Technology. An Authority of broad practical experience in Electrical and Mechanical Engineering.

ARTHUR H. WILLIAMS, Vice-President, in charge of Engineering, Shafer Bearing Corporation.

Awards as stated above will be made on the basis of the merit in whatever ideas are submitted as valuable contributions to the art of design, manufacture, application or use of Shafer Self-Aligning Bearings. The opinion of the judges will alone determine the relative merits of any ideas submitted and all decisions of the judges will be final. In the event of any ties, identical or duplicate awards will be made. The Shafer Bearing Corporation reserves the right to adopt or make use of any ideas submitted.

There are no restrictions as to entrants, number of entries, or the form in which the latter are made. All entries received on or before September 1, 1944 will be eligible and awards made as soon as possible thereafter. Winners will be notified by mail and announcements in magazines of national circulation.

Address all entries to the Shafer Achievement Awards Committee

Shafer Bearing Corporation

1426 W. Washington Blvd., Chicago 7, Illinois

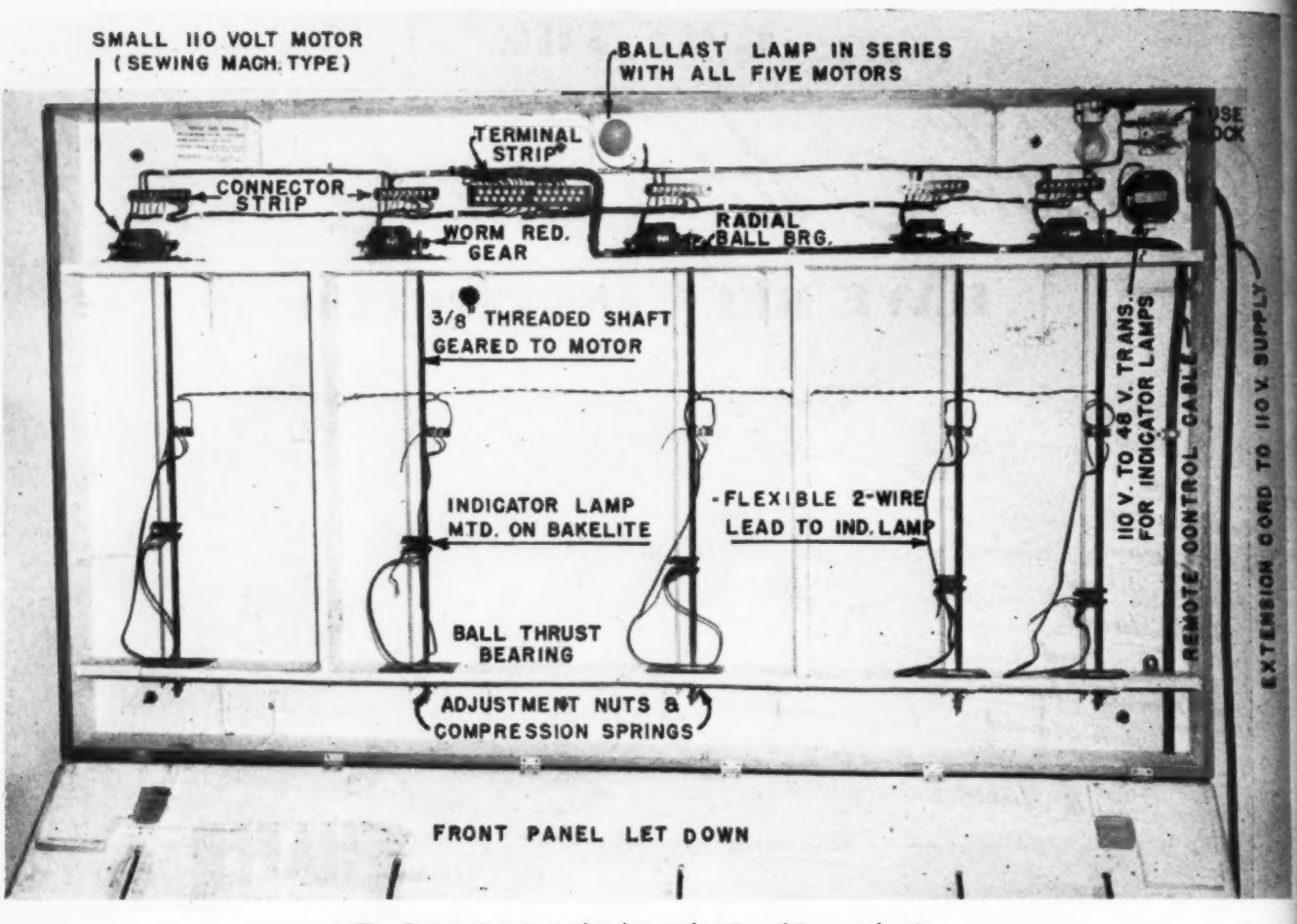
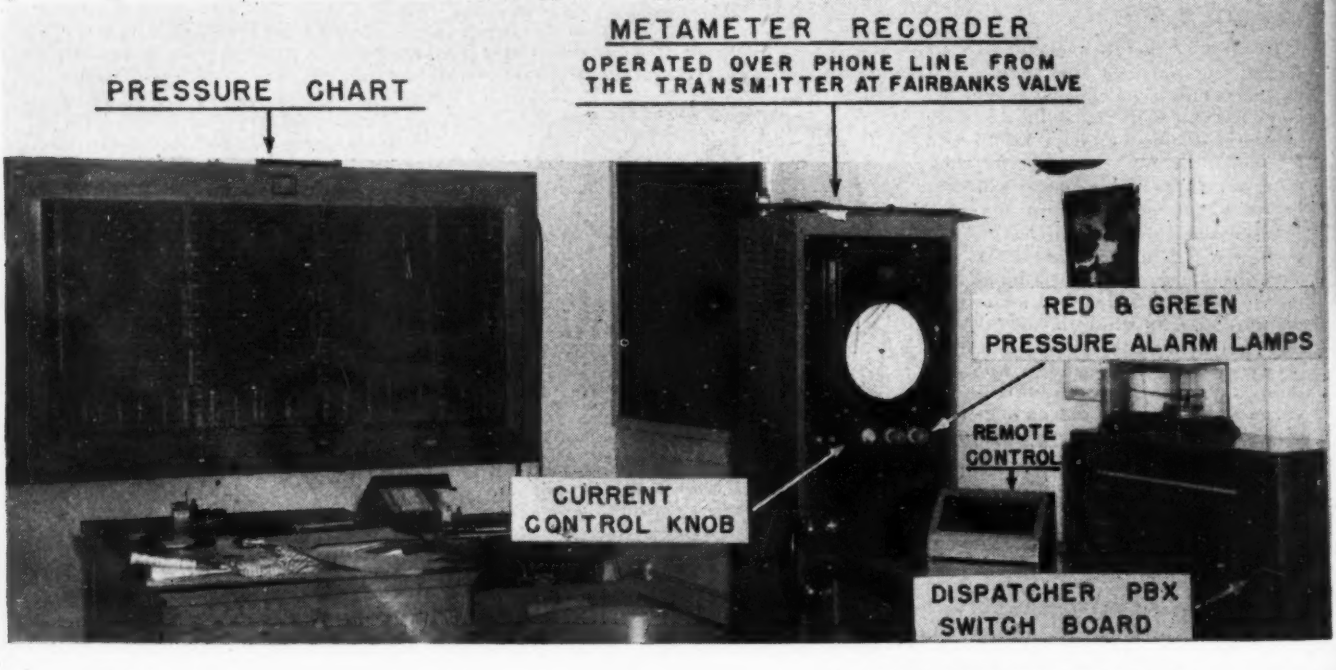


Fig. 2. Interior view of cabinet showing drive mechanism

viously, the safe working pressures are reduced with each change of thickness. The line is being operated at a safety factor of three, which is drawn in steps across the chart.

There is of course a limit to the intake pressures that can be carried, also a limit to the discharge pressures downward or reverse. For example, when the pressure at the Beaumont end becomes too low for satisfactory service, a red indicator warns the dispatcher that he should call on Vanderbilt for more gas (assuming that no break or leak exists). This same rule applies to other points along the line. Even inexperienced dispatchers realize instinctively that a red light means "danger." In one case, a

Fig. 3. View of equipment in dispatcher's office at Houston



The high barium sulphate content of MAGCOBAR Mud Weight, unadulterated by any chemical, clay or bentonite, and its exclusive flotation process of manufacture which removes practically all of the low specific gravity matter found in the native barium sulphate, results in an unusually high specific gravity range of 4.35 to 4.45.

Because of the high purity of MAGCOBAR, the initial viscosity of MAGCOBAR mud is substantially lower and can be maintained with far less chemicals than muds weighted with other materials.

MAGNET COVE BARIUM CORPORATION

MALVERN, ARKANSAS — HOUSTON, TEXAS

lady dispatcher who was somewhat of a "rookie" called the superintendent out of bed to tell him that a certain light was in the red zone and asked him what to do. Thus the red warning signal averted a shut down despite a "green" dispatcher. It is evident, therefore, that although this or any other line can be successfully operated without such a device as the graphic chart described herein, the provision of such a tell-tale system is undoubtedly a practical contribution toward "foolproof" operation. It must be noted, however, that even the chart is of no value unless the dispatchers keep the pressure posted at all times.

The Valves

There are 16 valves along the entire line. Three of these, together with the transmitting and receiving stations, form the five key pressure points that govern the operation of the line.

As described in a previous article in *The Petroleum Engineer*,[1] the remote control telemeter equipment on this line in connection with the telephone communication system enables the chief dispatcher's office at Houston to know at all times the pressure at all five key points. The signals for all "metameters" are transmitted over the telegraph dispatching circuit without affecting the normal telephone service.

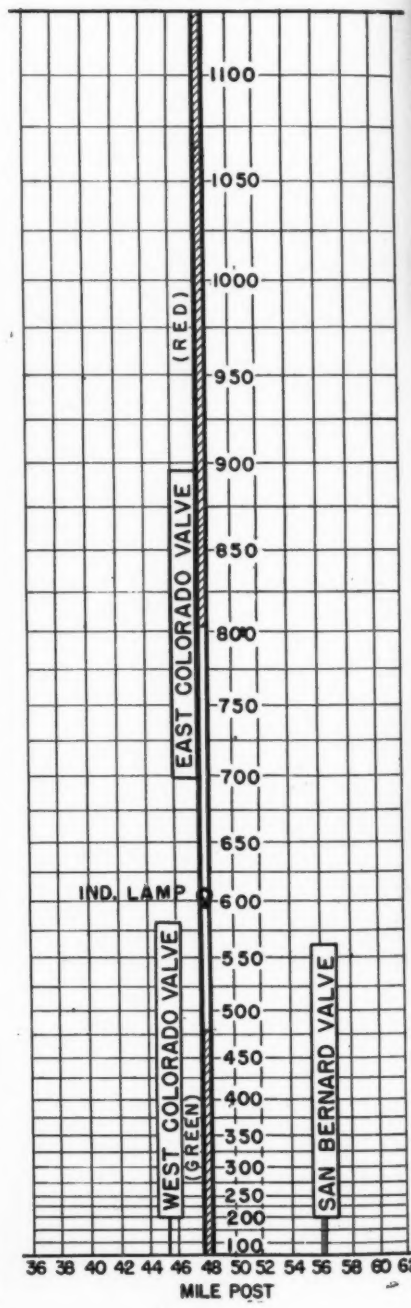
[1] "Communication and Signaling Features on New Line," by L. E. Adler, *The Petroleum Engineer*, March, 1942, P. 140.

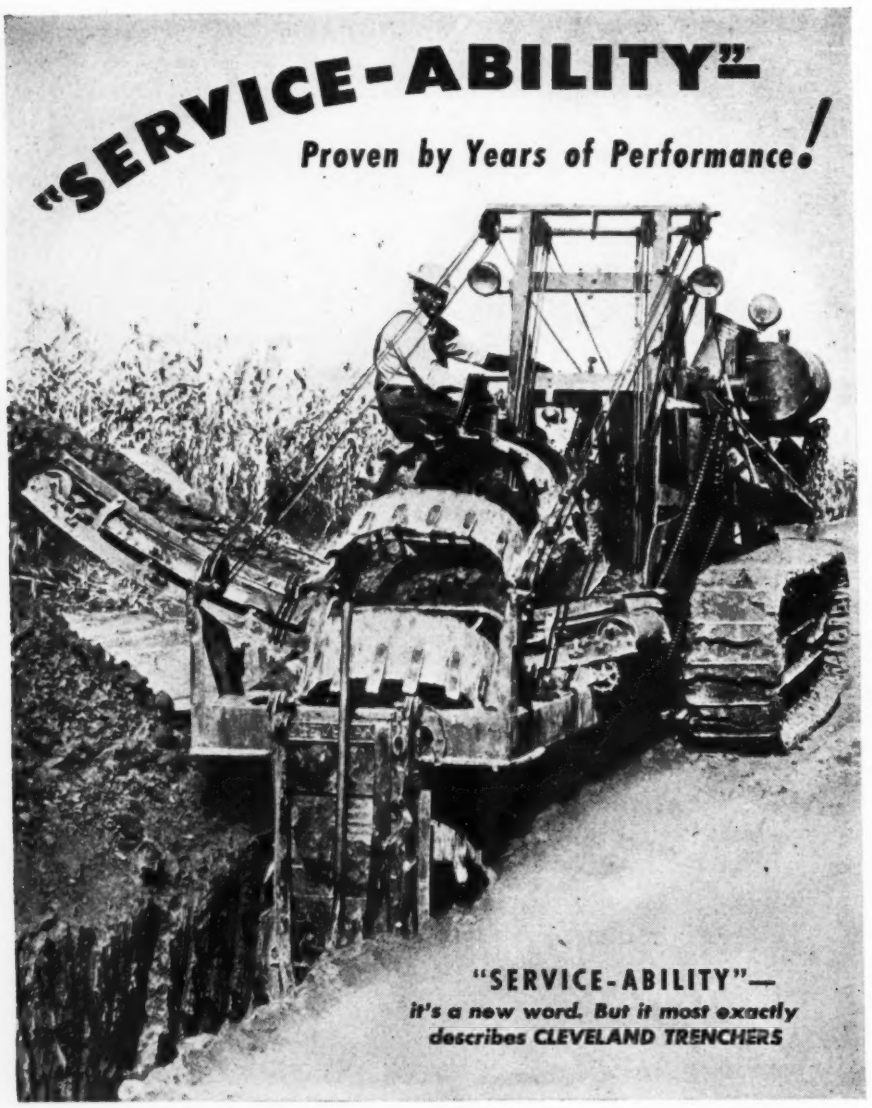
The Chart

The primary function of the chart is to indicate by green, red, or white lights the existing pressures at the five key points (Vanderbilt, East Colorado, Fairbanks, East Trinity, and Beaumont).

Another function is to enable the dispatchers (by means of the scaled chart, a straight-edge, and a little mathematics), to compute quickly the prob-

Fig. 4. Detail of a typical pressure slot on chart





• Many "Clevelands" built 15 to 20 years ago are still on the job today doing their part to ease the manpower shortage. • Although out-moded by "Cleveland's" modern standards of performance, this evidences the soundness and correctness of the basic design pioneered by Cleveland. • It also tells the story of "Cleveland's" policy of rendering prompt repair parts service even on these old machines. • This kind of service and this kind of ability are two more reasons why "Clevelands" continue to be the profitable long range investment in the trenching machine field. Guarantee yourself this "Service-Ability" in your Post-War trenching jobs by using Clevelands.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND 17, OHIO
"CLEVELANDS" Save More... Because they Do More

THE INSIDE STORY OF "Flow-pump" BETHLEHEM TUBING HEADS

They're highly convertible and interchangeable.

All use the same body, slips, and other similar equipment.

With the change of a very few parts, they fill all requirements from flowing through pumping.

For an economical standardization program to carry through the life of your well, specify Bethlehem "Flow-Pump" Tubing Heads.

. . . and CASING HEADS

A full line of slip-type, top-packed casing heads for medium-service wells.

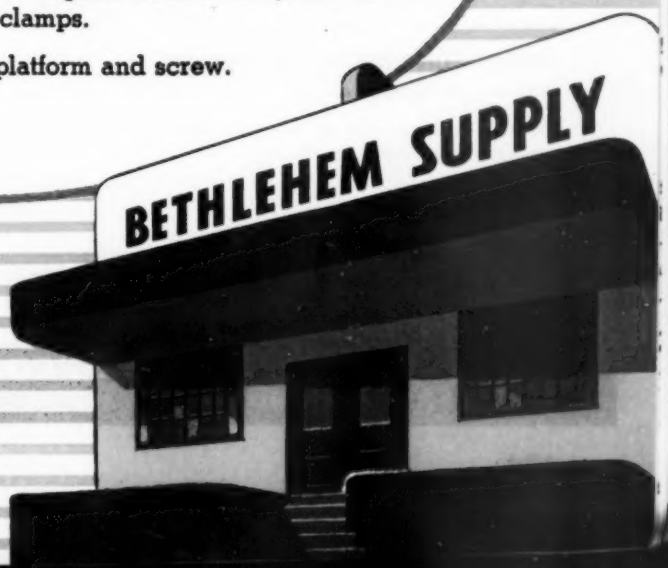
Designed and built to bring dependable slip-type casing heads within the economical range for all wells.

. . . and CASING RINGS

Dependable, sure, slip-type supports for your casing strings—designed especially for wells which do not require heads. They eliminate troublesome clamps.

Two types—platform and screw.

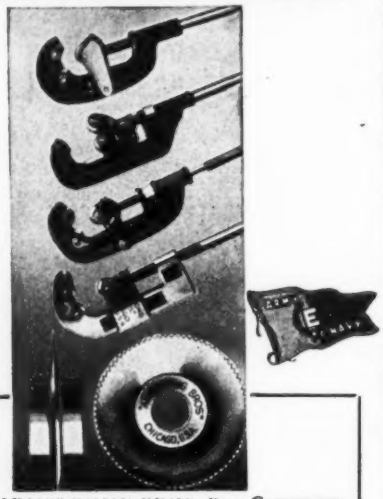
BETHLEHEM STEEL



Bethlehem Supply Offices or Stores: **Arkansas**—Magnolia; **Illinois**—Grayville, Salem; **Kansas**—Chase, Great Bend, Pratt, Russell, *Wichita; **Louisiana**—Harvey, Houma, Lakes Charles, New Iberia, Shreveport; **New Mexico**—Artesia, Hobbs; **Oklahoma**—Oklahoma City, Seminole, Tulsa, Wewoka; **Texas**—Alice, *Amarillo, *Beaumont, Borger, Bowie, Corpus Christi, *Dallas, *Fort Worth, Graham, Houston, Kamay, Kermit, Kilgore, La Ward, Odessa, Pampa, *San Antonio, Sundown, Wichita Falls, Winnsboro. (*Office only.)

Look for the *Arm-and-Hammer*

ARMSTRONG BROS.



All ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunder Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.

ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machines from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters.

Write for Catalog C-39a

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York

able location of a major leak or obstruction.

The chart consists of an oak wall cabinet 8 ft. long, 4 ft. wide, and 6 in. deep. (See Fig. 1). On the front is a drawing glued to a Masonite panel, on which is shown:

(a) Location of all valves, with mileage spacing and pressure scales, and

(b) Step-line of changes in pipe thickness.

At each of the five key pressure points on this map, there is a vertical slot ½ in. wide covered with a 1-in. plexite strip. Traveling upward or downward in each slot is a miniature "pin-point" 48-v. incandescent bulb, mounted on a bakelite carrier, which threads upward or downward on a vertical screw shaft. Fig. 2, showing the view inside cabinet with front down, gives on idea of the relatively simple drive mechanism.

Each plexite-covered slot is divided into three color zones, i.e., white for normal pressure range, red and green for abnormal pressures. For the Vanderbilt transmitting station, East Colorado valve and Fairbanks valve, red denotes abnormally high pressure and green low pressure. On the remaining two key points, these colors are reversed. The color zones are produced by merely slipping a 1-in. strip of red or green cellophane behind the strip of plexite at any desired location. Fig. 4 shows an enlarged view of a typical key-point slot taken from the face of the pressure-chart cabinet.

Control Cabinet

Fig. 3 is a general view of the dispatcher's office showing the metameter equipment that records pressures from the distant valve at Fairbanks. It also shows the control cabinet. The latter is equipped with an "up" and "down" push-button switch for each of the five key pressure points. The dispatcher merely presses the proper button, keeps his eyes on the chart, and releases the button the moment the lamp reaches the current pressure point on the slot.

The chart was designed and built about 18 months ago, and naturally as a war-built job embodies a few minor features that under normal circumstances would doubtless be regarded as makeshift. In general, however, it fulfills the purpose for which it was designed.

Acknowledgment

The writer is indebted to Don E. West of the Magnolia Petroleum Company and to the Southern Electric and Transmission Company for the use of material contained in this article.

SPERRY-SUN

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TO GET THE MOST OUT OF YOUR WELL SURVEYING EQUIPMENT?

We will gladly forward you a reprint of an article dealing with the subject, published in one of the well known trade magazines. Mail the coupon below.

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1608 Walnut St., Philadelphia 3, Pa.

Kindly mail me a copy of "Maximum Service from Well Surveying Equipment."

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SPERRY-SUN WELL SURVEYING CO.
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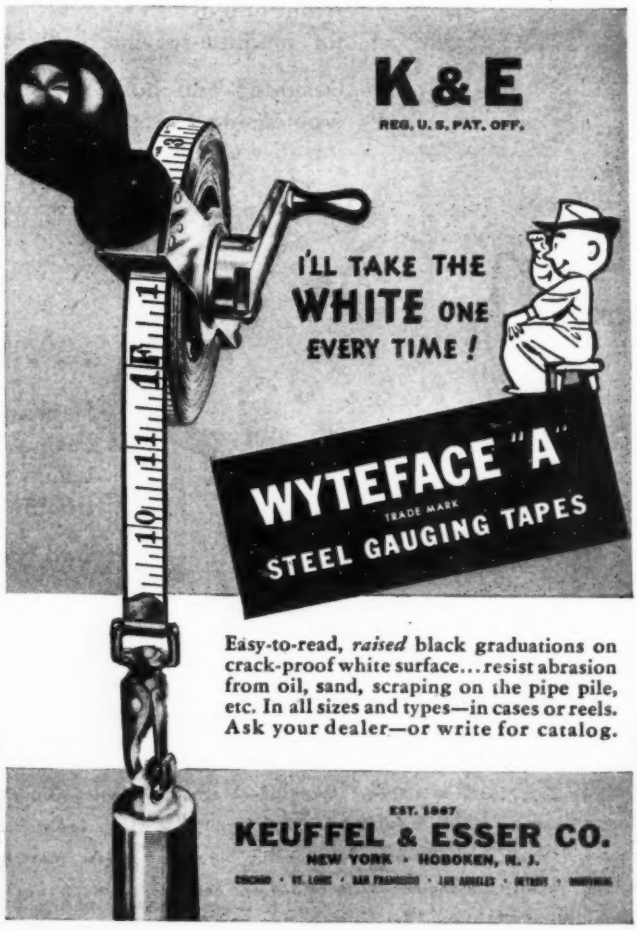


Easy-to-read, *raised* black graduations on crack-proof white surface... resist abrasion from oil, sand, scraping on the pipe pile, etc. In all sizes and types—in cases or reels. Ask your dealer—or write for catalog.

EST. 1867
KEUFFEL & ESSER CO.
NEW YORK • HOBOKEN, N. J.

Recognition FROM A HIGH

"For a number of years production operators have relied on the oil field supply companies for the multitude of shelf items currently required for production operations, and maintenance and repair use. A few well stocked supply house stores make it unnecessary for thousands of production operators to carry other than emergency stocks in their own warehouses. This practice has conserved both material and labor . . ."

FRANK A. WATTS, Director of Materials, Petroleum Administration for War.

IN WAR AS IN PEACE, JARECKI STORES ARE *YOUR* STORES

They are conveniently located in all active fields, with stocks geared to the needs of the territory they serve.

They are managed by friendly, experienced men who take a personal interest in your supply problems and do everything humanly possible to meet them.

Back of them is a tradition of service dating back to the earliest days of production. To generations of operators they are the first source of supply.

JARECKI

MANUFACTURING COMPANY

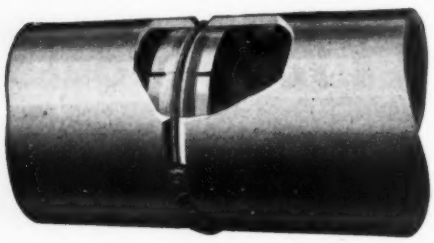
"Since 1852"

General Offices: St. Louis, Mo. Home Office and Factory: Erie, Pa., U. S. A. District Offices: Tulsa and Bartlesville, Okla.; Dallas and Houston, Texas; Mt. Pleasant, Mich.; Centralia, Ill.

BRANCH STORES AT ALL IMPORTANT PLACES IN THE OIL COUNTRY

for REFINERY and PIPE LINES use WEDGE Split CHILL RINGS

Wherever pipe is welded — in the Refinery or Pipe Lines — the use of WEDGE Chill Rings with the patented SPLIT Feature will assure a BETTER job. The outstanding fact is that WEDGE Chill Rings REINFORCES the joints and make them the STRONGEST part of the line. In case of shock, strain or vibration the pipe will fail



before the reinforced joints. It is possible to weld FASTER and do a BETTER job even with less skilled help and skilled help can do considerably more. The cost of WEDGE Chill Rings is far offset by the MANY savings they make. They enable you to align pipe sections faster and weld faster, using fewer welding electrodes.

Write for Information

WEDGE PROTECTORS, INC.
9522 Richmond Ave., Cleveland 5, Ohio

WEDGE
Split CHILL RINGS
SAVE MONEY

Running Tour

WITH MEN IN THE INDUSTRY

ERROL J. GAY, chief technical adviser for Ethyl Corporation, has been awarded the first citation given by the army to an oil man in a civilian capacity in World War II. Gay was presented with a ribbon and citation for meritorious service in his work as a civilian technical consultant in the Fuels and Lubricants Division, office of The Quartermaster General.

FIRST LT. JOHN ROBERT FLUOR, a bomber pilot of the Seventh Army Air Force, was decorated with the air Medal for extraordinary bravery and valor in action against the Japs over the Marshall Islands. Lieutenant Fluor is the son of P. E. Fluor, vice president and general manager of The Fluor Corporation, Ltd., Los Angeles.

JAMES C. GILBERT has been made superintendent for the Husky Refining Company at Cody, Wyoming. He was formerly superintendent for Barnsdall Oil Company, Los Angeles, California.

LT. COL. JACK A. BARNES, who in civilian life represented Trinity Portland Cement Company, is now stationed at headquarters of the 35th Infantry Division, Camp Butner, North Carolina.

CECIL S. SIMON, 54, sales engineer for Midwest Piping and Supply Company, died May 18 in Tulsa, Oklahoma. He was a graduate of Leland Stanford University and had been associated with Midwest more than 20 years.

L. F. SCHERER, who has been on leave of absence more than a year, has returned to his duties as assistant chief engineer with The Texas Pipe Line Company, Houston, Texas. While on leave Scherer was connected with the War Emergency Pipeline, Inc.

JOHN BAIRD of Lubrizol Corporation was elected chairman of the Mid-Continent section of the Society of Automotive Engineers. JOHN V. BRAZIER of Bareco Oil Company is vice chairman; LESTER KAMPMIER of Phillips Petroleum Company, treasurer, and W. L. THOMPSON, Mid-Continent Petroleum Company, secretary.

ALFRED H. (TED) SMITH, 56, pioneer oil man, died in Los Angeles, California, May 30. Smith went into oil development after he went to Houston, Texas, in 1912. He and his partner, J. W. Cain, had substantial holdings in Southwest Texas.

GEORGE J. HANKS was elected vice president and director of South Penn Oil Company following his resignation as vice president and director of the Tide Water Associated Oil Company. The post was left vacant last December by the death of C. F. Stevenson.

PAUL D. WILLIAMS has joined the staff of the Western Petroleum Refiners Association as technologist. Williams has been connected with several refining companies in Oklahoma and Kansas and was chief chemist for the Oklahoma Corporation Commission.

DREW L. HINES has been appointed manager of transportation and supplies, Tide Water Associated Oil Company, eastern division, with headquarters in New York. He succeeds former Vice President George J. Hanks, who resigned. Hines has been with the company more than 21 years.

J. A. "COTTON" ROBBINS, for the past 18 years associated with the purchasing department of Pure Oil Company, has resigned effective July 1 to join George E. Thompson and Associates, outdoor advertising specialists of New York City. Robbins will be the Chicago district manager with offices at 333 North Michigan Building.

WILLIAM P. HEADDEN has been appointed assistant manager of the sales engineering department of the Standard Oil Company of New Jersey. A graduate of Rensselaer Polytechnic Institute in 1929, Headden joined Standard as a student engineer.

I. K. FARLEY, who has been representing the industrial division, Brown Instrument Company, Minneapolis-Honeywell Regulator Company, in St. Louis, has been appointed sales engineer for the petroleum engineering and contracting industry in the New York metropolitan area.

FIRST LINE OF FIGHTING STEEL

Batteries of open-hearth furnaces in the steel mills of America produce most of the steel for the attack. For the open-hearths are the first line of steel production — and steel is the spearhead of invasion.

New skills and new methods in open-hearth operation contribute to the record-breaking steel production that arms our men and our allies and affords protection to their lives as well.

This greater open-hearth tonnage of new carbon steels, with properties approaching the alloys, holds high promise for peacetime application in great abundance that will enrich life and enlarge daily living.

JONES & LAUGHLIN STEEL CORPORATION
PITTSBURGH, PENNSYLVANIA

J&L STEEL

CONTROLLED QUALITY STEEL FOR WAR

THE OPEN HEARTHS

Bigger than 8-room house, a modern open hearth steel furnace, enclosed in silica brick, produces 150 to 200 tons of molten steel every 10 to 12 hours. The furnace is first charged with limestone, then scrap iron, eventually pig iron or molten iron, and other ingredients. For hours the "bath" melts, bubbling and boiling at temperatures up to 3,000°F., is worked, watched and tested by skilled crews, vigilant to maintain control of quality.

Samples of the steel bath are taken at intervals and laboratory tested to make sure analysis of the steel is correct for the job it is to perform—perhaps on a far away battle front. Experienced open-hearth melters and helpers, by merely looking at a fractured steel sample, can judge carbon content to within 2/100 of 1%. In this they are now assisted by a magnetic device in a small box which reveals carbon content on a dial. This is the "Carbanalyzer," a J&L invention.

Through tap hole in rear wall the "heat" of molten metal is drawn off into great ladles in pits below. As these are filled, protectively garbed skilled workmen on the tapping platforms amidst heat and sparks, throw in measured quantities of manganese, silicon and other final modifying ingredients (see illustration) to obtain exact analysis of steel desired.

Wispy vapors tinted lavender, chartreuse, pink, blue, yellow, arise as the fiery stream of steel gurgles and splashes until ladle is full, and steel sparks shower about, popping and bouncing as they hit the ground. Overhead crane now picks up the sputtering brimful ladle and bears it away to fill the rows of ingot molds standing close by on low-built buggies (small flatcars).

Greatest steel producers of all time, open hearth furnaces, from which streamed last year in the U. S. 78,625,857 tons of steel ingots, were invented by Charles William Siemens, of Hanover, Germany, who became citizen of England to obtain protection of its patent laws. He patented his furnace in 1861 and perfected it in 1867, a dozen years after Henry Bessemer's process had revolutionized steel making.

Two brothers in France, Emil and Pierre Martin, experimenting in the 60's to further improve steel-making methods, utilized a Siemens furnace to produce steel by melting scrap iron in bath of molten pig iron. This became known as the Siemens-Martin process; is substantially the process used today.

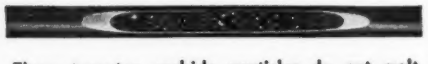
A Cleveland ironmaster, Charles A. Otis, founder of Otis Steel Co., in association with Samuel F. Wellman, engineer, of New York, in 1873 built first complete steel works in U. S. planned exclusively for production of steel by the acid open hearth process. In 1880 Wellman built for Otis first basic open hearth steel furnace in U. S. (Basic differs from acid process.) Otis Works, Cleveland is now one of Jones & Laughlin's big steel plants—others are in Pittsburgh and Aliquippa, Pa.

Tube Borium Keeps 'em digging

DULL IN 3 DAYS
STILL SHARP AFTER 30 DAYS
STOODY TUBE BORIUM* KEEPS DITCHER TEETH SHARP ...ELIMINATES FREQUENT SHUT-DOWNS FOR TOOTH CHANGES...CUTS REPLACEMENT COSTS UP TO 75%

The two ditcher teeth pictured above were used on the same machine and operated under identical conditions.
The unprotected tooth at the top had to be sharpened every three days and was too short for further service after six sharpenings.
But the Borium-protected tooth at the bottom operated for 40 days and wore only ½". It was simply resharpened in the forge, retipped with Tube Borium, and put back on the ditcher for another 40 days' service.
Before the tooth was finally worn out, it had operated a total of 120 days!
Tube Borium makes such savings possible because the deposits represent the ultimate in wear resistance and the ability to cut hard earth formations.

*Stoody Tube Borium is supplied in rods of ⅛", 3/16", ¼" and ⅜" diameters and is available for either oxyacetylene or D.C. electric application. Prices and specifications are yours for the asking.



These tungsten carbide particles do not melt when tube is applied but are held in suspension in a mild steel matrix forming a deposit resembling coarse sandpaper.

Send for free booklet on TUBE BORIUM, showing sizes and styles of rods and recommended methods of application.

STOODY COMPANY
1142 West Slauson Ave., Whittier, Calif.

STOODY HARD-FACING ALLOYS
Stop wear... Eliminate Repair

LAUGH WITH BARNEY

A housewife opened her refrigerator and found a little rabbit sitting inside. "What in the world are you doing in my refrigerator?" she asked. The rabbit peeped out and then craned its neck to catch a glimpse of the name plate on the icebox. "This is a Westinghouse, isn't it?" he asked. "Yes, it is," she replied, "but what are you doing in it?" "I'm just westing," the bunny replied.

When the name of the plaintiff was called out in court, much to everyone's amazement, he stood up in the jury-box.

"What are you doing there?" snapped the clerk.

"I was called to serve on the jury," was the meek reply.

"But you must have known you couldn't sit on a jury and try your own case?"

"I suppose not," admitted the plaintiff ruefully. "I did think it was a bit of luck."

"Now that I've told you about my past, do you want to marry me?" "Sure, baby."

"I suppose you'll expect me to live it down?" "No! I'll expect you to live up to it."

Guest: My dear, where did your wonderful string of pearls come from? You don't mind my asking, do you?

Hostess: Not at all—they came from oysters.

Sgt.: Do you know the difference between a popular girl and an unpopular girl?

Cpl.: Yes and no.

Have you heard about the baby kangaroo? He ran off and left his mother holding the bag.

A Harvard professor, traveling deep in the heart of Texas, found himself seated next to a Texas cowboy and fell into conversation with him. The Texan confessed to 87 years of age whereupon the professor said: "To what do you attribute your remarkable longevity?"

The Texan thought a moment and answered gravely: "Well, I never stole a horse and I never called a man a liar to his face!"

One wolf we know is too broke to buy etchings so he always asks his girl friends to come up and see the handwriting on the wall.

A true music lover is a guy who, hearing a blonde soprano singing in the bathtub, puts his ear to the keyhole.

They laughed when I came in with shorts on, but when I sat down they split.

Professor: What can you tell me about nitrates?

Student: Well, they are a lot cheaper than day rates.

"I never knew Walter had twins."

"Yeh, he married a telephone girl and she gave him the wrong number."

A negro boy, going through a cemetery, read this inscription on a tombstone: "Not dead, but sleeping." The lad scratched his head a while and remarked to himself: "He sho' ain't foolin' nobody but himself."

One Sunday morning, a young clergyman was hastily summoned by his bishop to preach in a certain church. To the congregation, which was entirely unknown to him, the young man spoke from the text: "Without money and without price."

The minister noticed, much to his astonishment and annoyance, that every time he quoted his text—and of course he quoted it rather frequently in the sermon's course—the entire congregation shook with suppressed laughter.

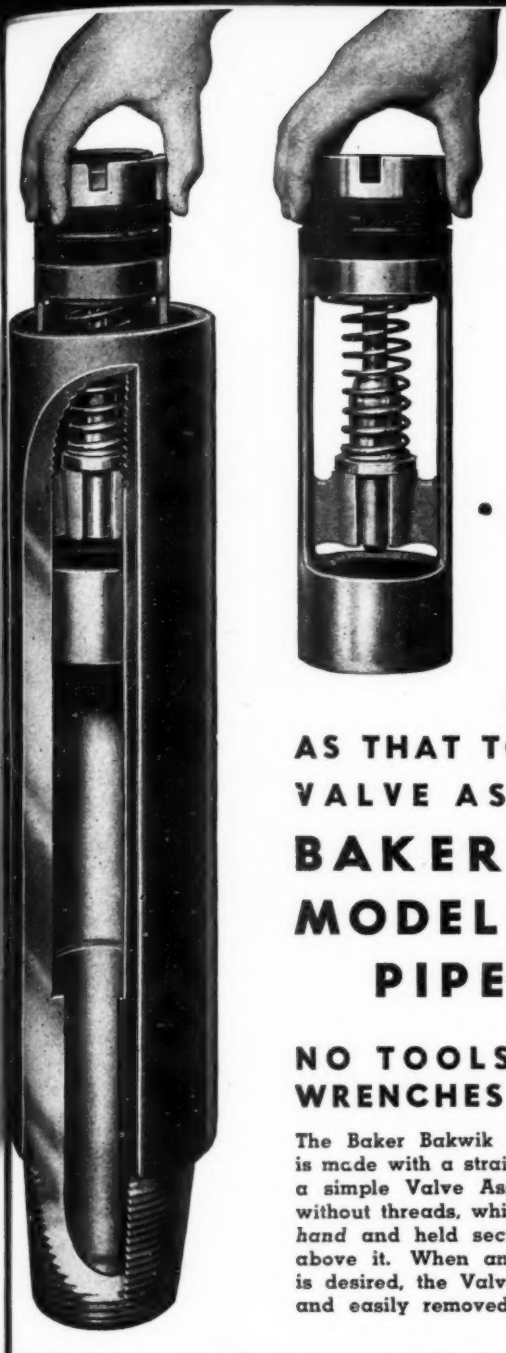
After the exercises were over the young divine asked one of the vestrymen the meaning of all that unseemly mirth.

The vestryman laughed heartily at this reminder and replied, "Our own minister—the one whose pulpit you filled today—is named Price, and he absconded yesterday with a large sum of money."

It was a hot August afternoon at one of our southern Army camps. A tough, seasoned sergeant had been drilling raw, awkward recruits until the men were ready to drop.

A captain, passing, paused for a moment to eye the spectacle with evident displeasure. An especially clumsy recruit had the ill luck, at that precise moment, to drop his rifle. The captain called the culprit out of line. "How long," he asked witheringly, "have you been in the Army?"

The recruit looked up, all the weariness and woe of the world writ upon his countenance as he stammered, "A—a-all day, Sir."



PICK IT UP

. . . and DROP IT IN!

IT'S AS SIMPLE AS THAT TO INSTALL THE VALVE ASSEMBLY IN A BAKER BAKWIK MODEL "B" DRILL PIPE FLOAT

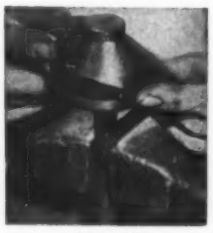
NO TOOLS OR SPECIAL WRENCHES ARE REQUIRED

The Baker Bakwik Model "B" Drill Pipe Float is made with a straight bore body and contains a simple Valve Assembly constructed entirely without threads, which is *dropped into place by hand* and held securely by the tool joint pin above it. When an unrestricted fluid passage is desired, the Valve assembly can be quickly and easily removed from the Float Body.

VALVE ASSEMBLY QUICKLY AND EASILY SERVICED

Replacement of the Valve Seal is ordinarily the only servicing required during the normal operation of the Baker Bakwik Drill Pipe Float Valve Assembly . . . and this operation can be quickly accomplished in the four easy steps illustrated. When it is necessary to replace the Side Seals, new ones can be installed with equal ease.

Step 1



Step 2

Step 3

Step 4

POSITIVE ACTING BACK-PRESSURE VALVE

At the slightest reversal of pressure, the Valve, with its recessed oil resistant Seal, instantly seats against the Valve Seat, creating a positive, leakproof seal. The two oil resistant Side Seals act against the Float Body to likewise form a positive seal.

The efficiency of the Baker Bakwik Drill Pipe Float has been proved in thousands of wells in oil fields throughout the world and is considered standard equipment where a positive back-pressure valve in the drilling string is desired.

THE BAKER BAKWIK DRILL PIPE FLOAT AFFORDS THESE IMPORTANT ADVANTAGES

1. It prevents plugging the bit.
2. It eliminates the annoyance of pulling wet strings.
3. It relieves weight on the derrick and rig equipment as well as on the lines and draw works.
4. It lengthens the life of wire lines and brake bands.
5. It minimizes — often prevents entirely — serious damage in the event the drilling string should part.
6. It prevents blow-outs through the drill pipe.

ALSO OF IMPORTANCE . . .

the fact that the Baker Bakwik Drill Pipe Float can easily be placed at any position in the drilling string; that the unit is designed for long life; that the Valve Assembly can be quickly and easily serviced on the rig floor; and that replacement parts can be secured at practically any Supply Store or Baker Warehouse.

Showing Bakwik Drill Pipe Float (complete with Valve Assembly) positioned in drilling string.

STRONG, SAFE VALVE ASSEMBLY CONSTRUCTION

Bakwik Drill Pipe Float Valve Assemblies are constructed of a minimum number of essential parts, each designed to give long, satisfactory service. The Cage is made of tough, abrasion-resistant steel, and the unrestricted opening through it is approximately the same area as the fluid passage through the tool joints. The Valve is made of special alloy iron cast integral with the steel stem. Both Valve and Valve Seat are ground to a perfect fit. The Valve Cage is constructed of close grained grey iron, carefully machined for accuracy. The Valve Spring is designed to perform long, efficient service. The two Side Seals and one Valve Seal are made of oil resistant packing, and afford maximum wear under all operating conditions.

BAKER OIL TOOLS, INC

MAIN OFFICE AND FACTORY: 6000 South Boyle Avenue, Box 127, Vernon Station, Los Angeles, California

CENTRAL DIVISION OFFICE & FACTORY: 6023 Navigation Blvd., Box 3048 Houston, Texas

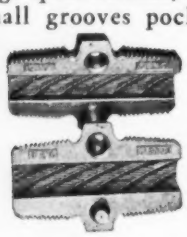
EXPORT SALES OFFICE: 19 Rector Street New York, N. Y.

MACHINERY and EQUIPMENT

Wire Rope Clamp

NATIONAL Production Company, 4561 St. Jean Avenue, Detroit 13, Michigan, has recently placed on the market four new sizes of its Safe-Line wire rope clamp, and now manufactures 13 sizes in all, ranging from 1/16 in. to ¾ in.

As shown in one of the accompanying illustrations, the clamps are made in two halves. The inside of each half is made to fit the rope; the large grooves pocket the large spiral strands; the small grooves pocket



each small wire that makes up the strands. The large grooves hold the rope from endwise slippage and the small grooves prevent the rope from spiral winding out of the clamp. Every strand, every surface wire, contacts the full length inner surface of the clamp. The two halves are gripped tightly on the rope with strong alloy steel nuts.

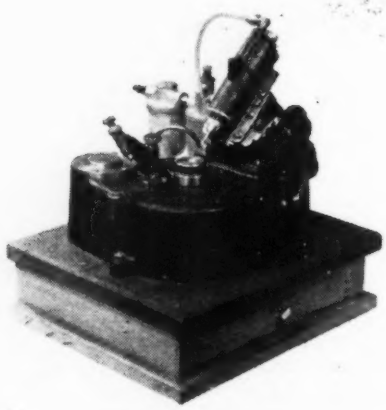
The simplicity of the clamp is an important feature, the manufacturer points out. It consists of but four parts and may be easily assembled and installed by unskilled workmen. The two taper threaded sections, which are placed on the exposed sides of the wire rope, are squeezed together in a vise-like grip when the two taper nuts are tightened. They grip the rope with a strength actually greater than that of the rope itself, it is stated.

Grinding Valve Seats

THE Cooper-Bessemer Corporation's need for a fast method to replace the hand lapping of the needle valves and valve seats in the fuel injection system of diesel engines was not answered in a readily available grinder of sufficient accuracy, so a machine was designed and made in the company's development laboratory.

Carl Mahaffey, development engineer for Cooper-Bessemer, has designed and completed the construction of this grinder after many months' experimentation. The performance of the grinder has enabled these valve seats to be turned out in quantity and with such precision that hand lapping is unnecessary.

The machine itself is powered by two air motors, one to drive the grinding tip and one to revolve the valve seat.



In the accompanying illustration is seen the motor for driving the grinder mounted at the angle of the seating surface of the valve base. The motor for driving the valve seat is enclosed and can be identified by the top-plate fastened by screws seen at the left.

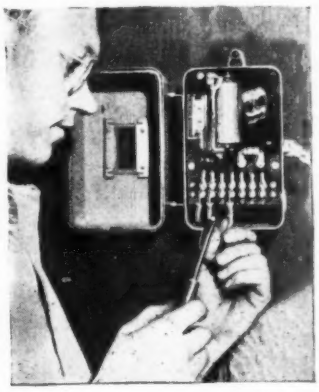
The valve seat is held beneath the knurled chuck seen immediately in line with the grinder shaft and is turned in the opposite direction to the grinding motion.

The driving air motor is of conventional design and is lubricated by a filter feed attached to the air line. The compressed air connection can be seen center-left of the illustration on the air filter, mounted in series with the oil filter, which is partially hidden by driving motor housing.

Another unusual feature of the Cooper-Bessemer valve seat grinder is the tool dressing point which is made a part of the unit. In the illustration can be seen the diamond point tool dresser, which is swung around into contact with the grinding tip when dressing is necessary.

Electronic Relay

A NEW electronic relay for amplifying the very limited current transmitted by delicate control contacts or high resistance circuits, thus



materially increasing the application range of many control devices, has been announced by the Industrial Control Division of the General Electric Company. Operated by any material having a resistance of from 0 to 500,000 ohms, or even greater if necessary, the new relay is especially suitable for controlling liquid levels in tanks and boilers, sorting metallic parts by size, detecting broken threads in textile machines, and as a limit switch requiring extremely light pressure to operate.

Small and light in weight, thus facilitating easy installation, the new relay consists of a standard type electronic tube, a supply transformer, and an electromagnetic relay—all mounted in a totally enclosed, weather-resistant enclosure suitable for wall or machine mounting.

In operation, the electromagnetic relay in the device is kept energized as long as the controls connected to the input grid circuit of the electronic tube remain open. The instant these contacts close, the relay is de-energized. A built-in time delay feature prevents chattering when the contacts in the input circuit are momentarily closed. A contact arrangement on the electromagnetic relay permits the device to be used either to make or break a load circuit when the actuating contacts connected to the input circuit on the electronic relay are closed.

Executive Vice President

H. N. Mallon, president of the Dresser Manufacturing Company, has announced the election of three vice presidents of the company.

J. B. O'CONNOR

J. B. O'Connor has been elected executive vice president. Arthur R. Weis and Lyle C. Harvey have been elected vice presidents.

O'Connor has been a director of Dresser Manufacturing Company since August 23, 1938. He is also vice president and general sales manager of Clark Bros. Co., chairman of the board of the Pacific Pump Works, and president of Bovaird and Seyfang, all subsidiaries of Dresser Manufacturing Company.

Weis is president of the Pacific Pump Works of Huntington Park, California, a Dresser subsidiary.

Harvey is president of the Bryant Heater Company of Cleveland, also a subsidiary.

C. P. Clark, president of Clark Bros. Co., who is already a vice president of Dresser will continue to serve in that capacity.

Buy Witte Engine

Oil Well Supply Company, a U. S. Steel subsidiary, has acquired the Witte Engine Works at Kansas City, Missouri, Fred F. Murray, president, announces. The Witte Engine Works will continue as heretofore in the manufacture of small gas, gasoline, and diesel engines. The acquisition will provide "Oilwell" with a line of engines for oil field pumping and other applications in industrial, agricultural, and general usage.

Edward H. Witte at the age of 77, retires from active direction of the company, which was founded by his father in 1870 and from whom he purchased it in 1886.

McKibbin to New Post

B. W. Clark, vice president of the Westinghouse Electric and Manufacturing Company, announces the appointment of John M. McKibbin as assistant to the vice president.

Formerly manager of the company's application data and training department, McKibbin's new responsibility will include all product and industry advertising, in addition to his present duties.

A native of Pittsburgh, McKibbin joined Westinghouse in 1922 as a member of the promotion division in Pittsburgh.

MOTHER EARTH IS GOING TO HAVE HER FACE LIFTED!

HYDRAULICS Rodgers KEEP THE WORLD MOVING

Manufacturers of:

UNIVERSAL HYDRAULIC PRESSES
TRACK PRESS EQUIPMENT
HYDRAULIC KEEL BENDERS
HYDROSTATIC TEST UNITS
POWER TRACK WRENCHES
HYDRAULIC PLASTIC PRESSES
PORTABLE STRAIGHTENER FOR PIPE AND KELLYS

SOUNDS like a rather ambitious undertaking, doesn't it, but that is more or less what is going to happen after this World Struggle is over. The Earth is in for a tremendous resurfacing operation.

The construction, road building and grading jobs for Crawler type tractors in that not too distant period are colossal. While our Plant is now engaged in essential work for the Armed Forces, we are not forgetting for a moment our duty and obligation to those who depend on Rodgers presses for quick repair of crawler tracks and other heavy machinery. Right *now* all engaged in essential work are eligible for Rodgers Hydraulic Track and Universal Presses. Wire or write for full information and prices. ***If it's a Rodgers, it's the best in Hydraulics.*** Rodgers Hydraulic Inc., St. Louis Park, Minneapolis 16, Minnesota.

Rodgers
HYDRAULIC Inc.

Petroleum Pioneers

A group of production and supply men of the California petroleum industry has recently been organized under the name of Petroleum Production Pioneers and held its first dinner meeting at the Clark Hotel in Los Angeles, May 18. Membership in the "Pioneers" will be limited to 250 for the duration of the war and of this number, four-fifths must have served 30 years or more in the oil industry. The present officers are S. H. Grinnell, president; Lou Bronzen, vice president; Richard Sneddon, secretary, and Glenn Merkley, treasurer.

The organization is based on the value of mutual benefits to be derived in maintaining and attracting contacts between the pioneers of the industry and the younger men. Pioneer members, now retired from active participation in oil development, believe that a void will be filled by the association by providing a means of keeping them in continuous contact with current events in the industry. The knowledge gained from men who pioneered the petroleum industry in California is expected to be of great assistance to younger oil management.

At the first meeting, S. H. Grinnell presided as chairman and Frank F. Hill was master of ceremonies. The keynote address was given by L. B. Little. The speaker representing the junior members was Lou Bronzen. Others who spoke included A. C. McLaughlin, R. E. Stearns, R. C. Stoner and W. L. McLaine. Ted Sutter was named to supervise and arrange for the writing of an accurate and comprehensive history of production and supply departments of the petroleum industry of California.

Among those present who had more than 50 years' service in the industry were: A. E. Fowks, 66 years; W. R. (Frosty) Martin, 63 years; C. E. Wilcox, 60 years; George Kamerer, 59 years; W. F. Dinger, 55 years; R. C. Baker, 51 years, and John Grier, Denny Driscoll, and R. W. Youngken, 50 years.

In the heaviest, most powerful machinery built . . . under terrific strains and impacts . . . where going is tough, punishment brutal and service continuous . . . there you will find AMERICAN SUPER HEAVY DUTY BEARINGS doing their job quietly, smoothly and efficiently.

AMERICAN SUPER HEAVY DUTY BEARINGS are designed especially for strenuous, gruelling, around-the-clock service. Their simple construction, absolute precision and tremendous strength assure longer, safer, lower-cost, trouble-free performance under the most adverse service conditions. Consult our engineering department for full technical details. Write TODAY!

AMERICAN ROLLER BEARING COMPANY
PITTSBURGH PENNSYLVANIA
Pacific Coast Office: 1718 So. Flower St., Los Angeles, Calif.

AMERICAN
Heavy-Duty ROLLER BEARINGS

Joins Moorlane Co.

Moorlane Company announces the appointment of C. W. (Hank) Harrington to the company's refinery equipment sales staff.

Harrington is well known throughout the Mid-Continent area, having served as district sales manager, with headquarters in Tulsa, for the Mexico Refractories Company of Mexico, Missouri, for 7½ years, and for the last 2½ years has been in the company's home office in charge of dealer and distributor business in the United States.

C. W. HARRINGTON

Harrington took up his new duties with the Moorlane Company, in Tulsa on June 1.

New Store

Bethlehem Supply Company has opened a new store at Winnsboro, Texas. D. G. Silvey is store manager and field representative. The store is under the general supervision of Fred Parks, district manager, who makes his headquarters at Dallas, Texas.

Field Sales Manager

A. M. Guthrie has been appointed field sales manager of The Buckeye Traction Ditcher Company with headquarters at Findlay, Ohio, the company's home office. He will be in charge of distributor policies and appointments through district managers.

Guthrie had been Buckeye's eastern district manager at Philadelphia, Pennsylvania, since January, 1940. Prior to joining Buckeye he was associated with the Paul Cochran Equipment Company in Chicago.

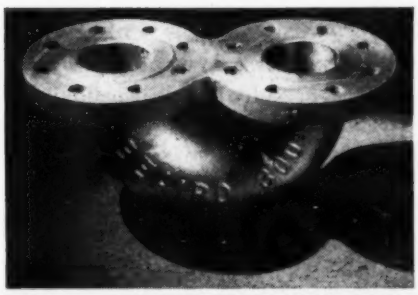
Extra QUALITY

SINCE 1918

BEAIRD

SHREVEPORT

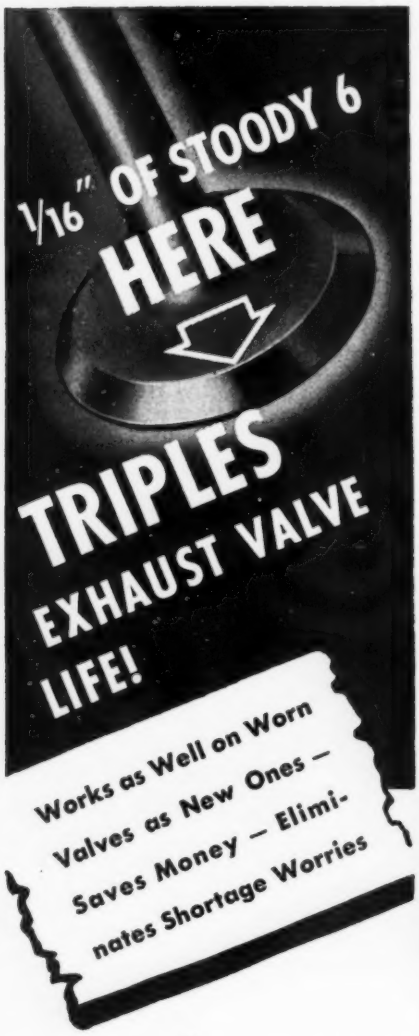
Heavy and uniform wall thickness and uniformity of flanges are characteristic of every fitting bearing the Beaird name. Accurate flange diameter, thickness and concentricity with the bore are accomplished by a complete machining of outer circumference and back face of flange, thus assuring ease of fitting and uniform bolt lengths. All Beaird standard fittings are made in strict accordance with Standard Oil Development Company specifications.



Before you place your next fitting order, consider the advantages of cast-steel fittings bearing the Beaird name and backed by twenty-six years of experience in engineering and manufacturing for the petroleum and allied industries. In addition to the large line of standard fittings our foundry has many special patterns available on order. The new Beaird Steel Fitting and Flange Catalog is now on the press. Write for your copy today.

THE J. B. BEAIRD COMPANY

6300 ST. VINCENT AVENUE — SHREVEPORT, LOUISIANA


1/16" OF STOODY 6
HERE
TRIPLES
EXHAUST VALVE
LIFE!
Works as Well on Worn Valves as New Ones — Saves Money — Eliminates Shortage Worries

AN ounce or two of Stoody 6 welded to new or worn exhaust valve faces adds 300 to 400 percent to their normal life, prevents burning, saves overhaul jobs, costs only a few cents per valve.

This folder outlines the simple procedure any garage or shop equipped with acetylene welding equipment can follow. Eliminates your worries about valve replacements and saves money as well.

Write for folder "Weld New Life Onto Worn Valves With Stoody 6" — no obligation.

STOODY COMPANY
1142 SLAUSON AVE., WHITTIER, CALIF.

STOODY 6 · THE METAL THAT ADDS EXTRA MILES TO EXHAUST VALVE LIFE!

Nomads Honored

Awards of distinguished service for having traveled abroad in the interest of foreign trade were presented several Nomads at the Harbor Day luncheon held in the Biltmore Hotel Ball Room, Los Angeles, May 25. Awards were made by the Los Angeles Chamber of Commerce during Foreign Trade Week. General chairman for Foreign Trade Week of 1944 was W. F. Bettis of M. O. Johnston Oil Field Service Corporation. Chairman of publicity was Hi Cassidy of McCarty Company. Chairman of the award committee was Wallace A. Sawdon of *The Petroleum Engineer*

Reading from left to right in the photograph are: (Top row) John F. Dodge, professor of petroleum engineering, University of Southern California; Tom Bannon, Oilfields Service Company; G. F. Van Loozen, The Lummus Company, and Bill McGraw, Western Pipe and Steel Company. (Seated) E. W. Forrow, Harvey Machine Company, Inc.; Paul Madearis, Madearis Oilwell Supply Company; Joe Siegel, Kobe Incorporated; Howard Harman, Smith and Harman; H. H. Peters, Technical Oil Tool Corporation, Ltd., and Paul Daniel, Daniel Orifice Fitting Company.

Other Nomads to whom awards were made but who were not present were: Earl M. Daniels, Hydril Company; Dan Duncan, Emsco Derrick and Equipment Company; C. Stewart Meece, (now in armed forces); O. W. Morgan (presented award but too late for photo), Byron Jackson Company; E. W. Plaugher, Axelson Manufacturing Company; Jack S. Smith, Byron Jackson Company; Fred L. Tyler, Reed Roller Bit Company, and Walter T. Wells, Lane-Wells Company.

AIC Officers

Dr. Gustav Egloff, director of research of Universal Oil Products Company, Chicago, was reelected president of the American Institute of Chemists at the annual meeting of the Institute in New York recently. Other officers were elected as follows:

Vice president, Dr. Donald Price; treasurer, Dr. Frederick A. Hessel, and secretary, Howard S. Neiman.

Elect A.P.I. District Officers

J. S. Montgomery, with Phillips Petroleum Company in Oklahoma City, was elected chairman of the Mid-Continent district of the American Petroleum Institute. He succeeds H. W. Ladd, Stanolind Oil and Gas Company, Tulsa, who was named chairman of the advisory board. L. N. Burkett, Carter Oil Company, Great Bend, was named vice chairman for Kansas; J. R. Evans, Stanolind, Tulsa, vice chairman for Oklahoma; D. J. Gribbon, The Texas Company, Pampa, vice chairman for the Texas Panhandle, and Wesley Moore, British American Oil Producing Company, Oklahoma City, secretary-treasurer.

Knowlton Leaves PAW

Donald R. Knowlton, Bartlesville, Oklahoma, has resigned as director of production of the Petroleum Administration for War. He has been on leave from Phillips Petroleum Company and has been promoted to manager of the foreign division of his firm.

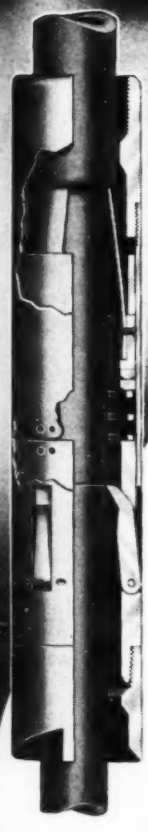
Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

PETROLEUM ENGINEER EDITION

Quick facts to know about PIPE CUTTERS

Whether it's an inside or outside job, read why these Baash-Ross cutters cut faster, cleaner, safer!



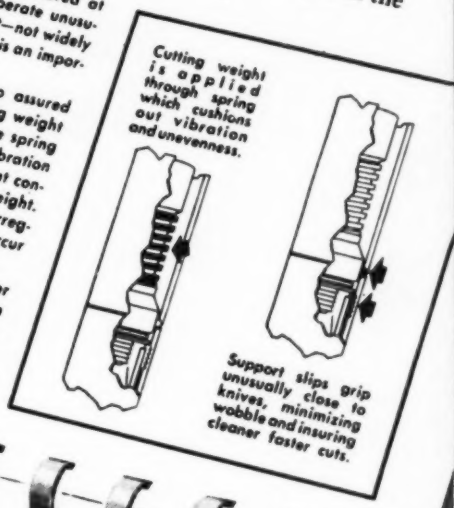
INSIDE CUTS

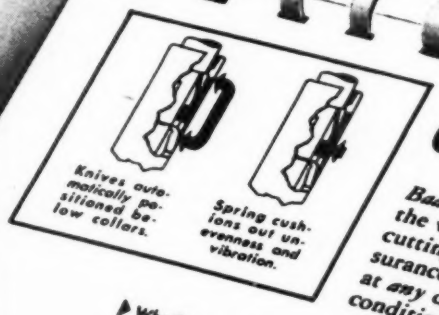
Baash-Ross Internal Pipe Cutters can be used to cut either tubing, casing, drill pipe or liners and require only minimum torque in the operating string.

▶ Lathe-smooth cutting action is assured at all times because the knives operate unusually close to the point of support—not widely separated from the support. This is an important feature to look for!

▶ Smooth effortless cutting is also assured by the "cushioned" feed. All cutting weight is applied to knives through a large spring which irons out all unevenness and vibration as the string rotates, yet permits instant control of the cut by varying the applied weight. This "cushioned" action eliminates the irregular feed and sudden "bites" apt to occur where weight is applied to bare knives!

▶ With this cutter you can make any number of cuts on one run. Particularly valuable in salvage work. If not sure where pipe is stuck, start low and make successive cuts up hole until pipe is freed. Saves crew time, speeds recovery!


Cutting weight is applied through spring which cushions out vibration and unevenness.
Support slips grip unusually close to knives, minimizing wobble and insuring cleaner faster cuts.



OUTSIDE CUTS

Baash-Ross External Pipe Cutters hold the world's depth record for successful cutting jobs—14,366 feet . . . giving assurance of maximum safety in *any* well at *any* depth and under *any* operating conditions.

▶ Whether it's drill pipe, casing or tubing, they cut and recover on one trip, eliminating need for extra overshots or wasted trips.

▶ They enable you to recover pipe in long undamaged sections—often several hundred feet at a time—thus reducing number of trips required as well as minimizing pipe damage.

▶ Simple and positive in operation, these cutters automatically space the cut a short distance below collars and joints, further reducing pipe damage and also assuring cuts at thinnest pipe section.

▶ Cutting weight is cushioned by spring to assure smooth vibrationless action and uniform feed at all times, regardless of unevenness in operating string.

Available in types to cut all drill pipe, whether flush joint, API Regular or Upset. Also all sizes tubing and casing.

The brief facts cited above are only a few of many unique features incorporated in Baash-Ross Cutters. But they serve to show why Baash-Ross Tools are recognized throughout the world for their efficiency, safety and rugged dependability. No matter what your fishing job, call Baash-Ross! (Baash-Ross Cutters are leased in U. S. A. . . Sold for export only.)

Say "DOUBLE E" WHEN YOU WANT . . . .

The Best
VALVE-IN-HEAD PACKER

The Double "E" Valve-In-Head Packer was designed to cover every use expected of the conventional type packer but to eliminate the dangerous characteristics of the hookwall type.

By using the cup type packing, you know that any increase in fluid or gas pressure will increase the seal between the cup and casing wall. There is no tendency to have the fluid channel past the packing, and the small cup area contact prevents sticking.

The elimination of slips prevents wedging in the hole and prevents ratcheting of the packer up the hole in pumping wells. The packer will *breathe* with the tubing. To raise or lower the packer, just open the valve.

Tubing will hang straight in the well, thus eliminating needless rod and tubing wear.

"DOUBLE E" Products

EQUIPMENT ENGINEERS
INCORPORATED
2039 AMELIA STREET
DALLAS 9, TEXAS

Pure Oil Purchasing Department Has Party

Shedding the cares of the day for a bit of relaxation, the personnel of the purchasing department of the Pure Oil Company, Chicago, together with a group of friends in the oil equipment supply business, recently joined for an evening of relaxation and fun. In the photograph, unless otherwise identified, all are members of the general purchasing agent's office. Front row, left to right: Josephine Derrig, Ruth Haffard, Jean McGowan, Carl C. Egner, Oil Well Supply Company, Rita McGoorty, Lucille Racette, and Beatrice Austin. Second row: G. L. Parsons, general purchasing agent, Harold Nilson, Norma Sundquist, Evelyn Dorff, Lucile Schirmer, Nancy McGrew, Dorothy Hoyer, Betty Schneider, Margaret Williams, E. J. Mullaney, assistant general purchasing agent, Peggy Blanchfield, and A. W. McInerney. Third row: W. O. Massey, L. M. McClure, Harry Weber, Walworth Company, H. V. Melick, R. D. Mueller, Irene Albrecht, Peggy Behler, Dolores Middendorf, Mildred Seelbach, Furness Prell, Hughes Tool Company, and T. G. Creekbaum. Top row: H. A. Lovelady, Jones and Laughlin Supply Company, L. J. Mehl, C. F. Ashbaugh, W. F. Cook, Stanley Loss, J. H. Harmon, M. E. Baker, Jene Harper, Franklin Supply Company, W. C. White, Illinois Producing Division of Pure Oil Company, C. F. Brehmer, Ray Cronin, J. A. Robbins, and J. A. Shock.

Cudlipp Reelected

Al E. Cudlipp, of Lufkin, vice president of Lufkin Foundry and Machine Company, was reelected president of the Texas Motor Transportation Association at the close of the annual meeting held in Fort Worth.

AL CUDLIPP

Other officers are Fred Gillette, of Dallas, vice president; J. A. Fadell, of Fort Worth, treasurer, and Lynn B. Shaw, of Austin, reelected general manager.

Powell Company Officers

At the annual meeting of The Wm. Powell Company, the following were reelected to office: H. H. Coombe, chairman of the board and treasurer; James Coombe, president and general manager; Geo. E. Weitkamp, first vice president and secretary; David Forker, vice president; Oliver F. Gang, vice president; Wm. Heilig, vice president, and Elmer R. Noll, vice president.

The board of directors also announced the election of the following additional vice presidents: Wm. R. Kraus, Wm. E. Minor, Harry C. Morine, E. K. Pierce, and E. W. Voss, and of Wilton Husing, as assistant to the president.

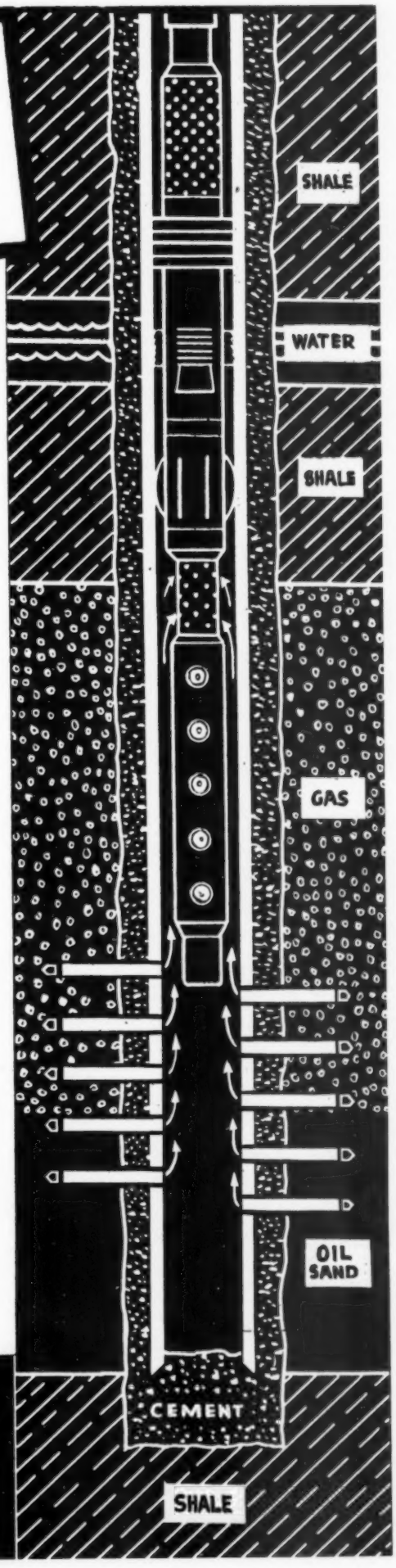
Made Sales Manager

Frank W. Bemis has been appointed sales manager of the American Cable and Hazard Wire Rope Divisions of American Chain and Cable Company, Inc., with headquarters at 230 Park Avenue, New York. Bemis has been with the company since 1938.

Gaso Receives Award

Gaso Pump and Burner Manufacturing Company, Tulsa, Oklahoma, on May 19, received the Army-Navy "E" production award.

McCullough
COMBINATION GUN PERFORATOR and TESTER ADVANTAGES
Brown Line Print *No. 9*



FOR GREATER SAFETY FROM BLOWOUTS . . . GUN PERFORATE AND TEST IMMEDIATELY

With a single run of the McCullough Combination Gun Perforator and Tester you quickly and safely accomplish these results:

1—Test the cement or squeeze job.

2—Perforate the casing.

3—Test the formation.

Maximum safety from blowout hazards is assured by eliminating the round trip of the tools required for testing in the ordinary way. With the McCullough Combination Gun Perforator and Tester, you gun perforate and then test immediately—there is no unguarded time interval during which the fluid column can become gas cut. After the test is completed, heavy mud can be circulated into the well, if desired, before removing the Tester and tubing.

Get greater safety from blowouts—save rig-time and manpower—get the combination gun perforator and tester that gets results. Ask the nearest McCullough service man for full information.

Refer to your 1944 Composite Catalog for a description of the

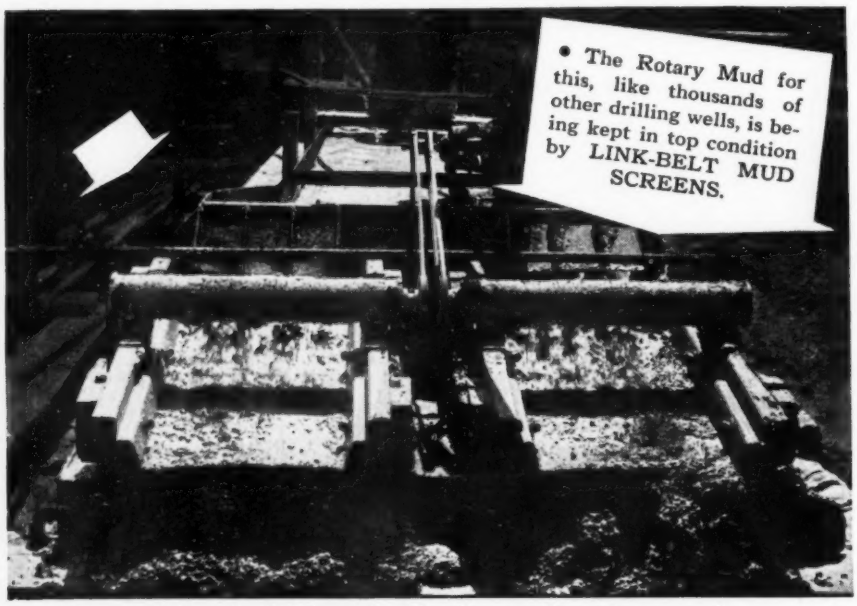
Hard Shooting-exact SPACING

McCullough
Combination
GUN PERFORATOR and TESTER

22 SERVICE LOCATIONS

McCULLOUGH TOOL COMPANY . . . 5820 South Alameda Street, Los Angeles 11, California
Export Office: 30 Rockefeller Plaza, New York 20, N.Y.

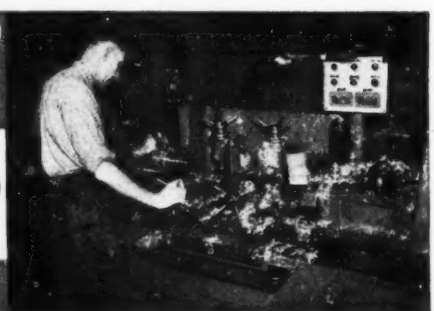
HOUSTON, TEXAS	TYLER, TEXAS	SHREVEPORT, LA.	CASPER, WYO.
WICHITA FALLS, TEXAS	McALLEN, TEXAS	HOUMA, LA.	LOS ANGELES, CALIF.
VICTORIA, TEXAS	ALICE, TEXAS	LAKE CHARLES, LA.	VENTURA, CALIF.
CORPUS CHRISTI, TEXAS	MAGNOLIA, ARK.	OKLA. CITY, OKLA.	BAKERSFIELD, CALIF.
GEO. WEST, TEXAS	NEW IBERIA, LA.	SEMINOLE, OKLA.	AVENAL, CALIF.
ODESSA, TEXAS			SACRAMENTO, CALIF.

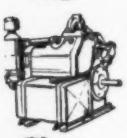
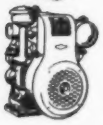


Shale and other damaging abrasives continuously removed
LINK-BELT COMPANY, Philadelphia 40, Houston 2, Dallas 1, Los Angeles 33, New York 7, Toronto 8. Sold by most supply houses 9271

LINK-BELT MUD SCREEN

DIAMOND-BORED RODS
Another **"HIDDEN VALUE"**
IN ALL WISCONSIN *Air-Cooled* ENGINES



Absolute uniformity and close-tolerance fit of all connecting rod bushings are direct results of the unique machine operation illustrated above. Each rod is rigidly locked in precisely the same position, and diamond-pointed bits machine both ends of every rod with uncanny smoothness and perfect mechanical precision. All of this helps to produce a quiet, smooth-running engine, designed and built for heavy-duty service all the way through.

All of this adds up to highly satisfactory *end use* on your equipment.

Most H.P. per pound
WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines
WRITE TO HARLEY SALES CO. 510 ATLAS BLDG., TULSA, OKLA. M & M BLDG., HOUSTON, TEXAS OIL FIELD DISTRIBUTOR FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

Joins Cooper-Bessemer

The appointment of William F. Lamoreaux to the position of research metallurgist has been announced by The Cooper-Bessemer Corporation.

W. F. LAMOREAUX

Lamoreaux, who for the last 3 years was director of research for the Meehanite Metal Corporation, will divide his time between the company's two plants, at Mount Vernon, Ohio, and Grove City, Pennsylvania. At the outset, he will undertake an even closer integration of the company's engineering, metallurgical, and foundry efforts, which already have produced many notable developments in foundry technique.

Garris Passes Away

Joseph McClintock Garris, manager of the sling division of Macwhyte Company, Kenosha, Wisconsin, passed away May 25 as the result of a heart attack. Garris held several basic patents on slings, notably his Atlas braided wire rope sling manufactured by Macwhyte. He joined Macwhyte Company in 1931.

J. M. GARRIS

His son, Erwin F. Garris, who has been his assistant, succeeds to his father's post.

Emsco "E" Award

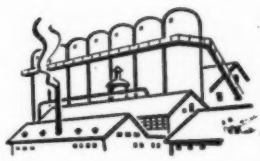
For high achievement in the production of war materials, the employees of Dallas plant, D + B Division, Emsco Derrick and Equipment Company, were recently presented the coveted Army and Navy "E" award by the War Department.

Presentation of the award was made by Lt. Colonel R. W. Coward, Executive Officer, St. Louis Ordnance District and was accepted on behalf of the company by B. M. Caldwell, manager of the Dallas plant, and R. H. Miller, employee representative.

The "E" pins were presented by Lt. Commander J. F. Livers and were accepted for the employees by J. G. Hast and R. A. Murphy.

H. H. Glen, president of the Emsco Derrick and Equipment Company, also spoke, complimenting the employees on their outstanding production effort.

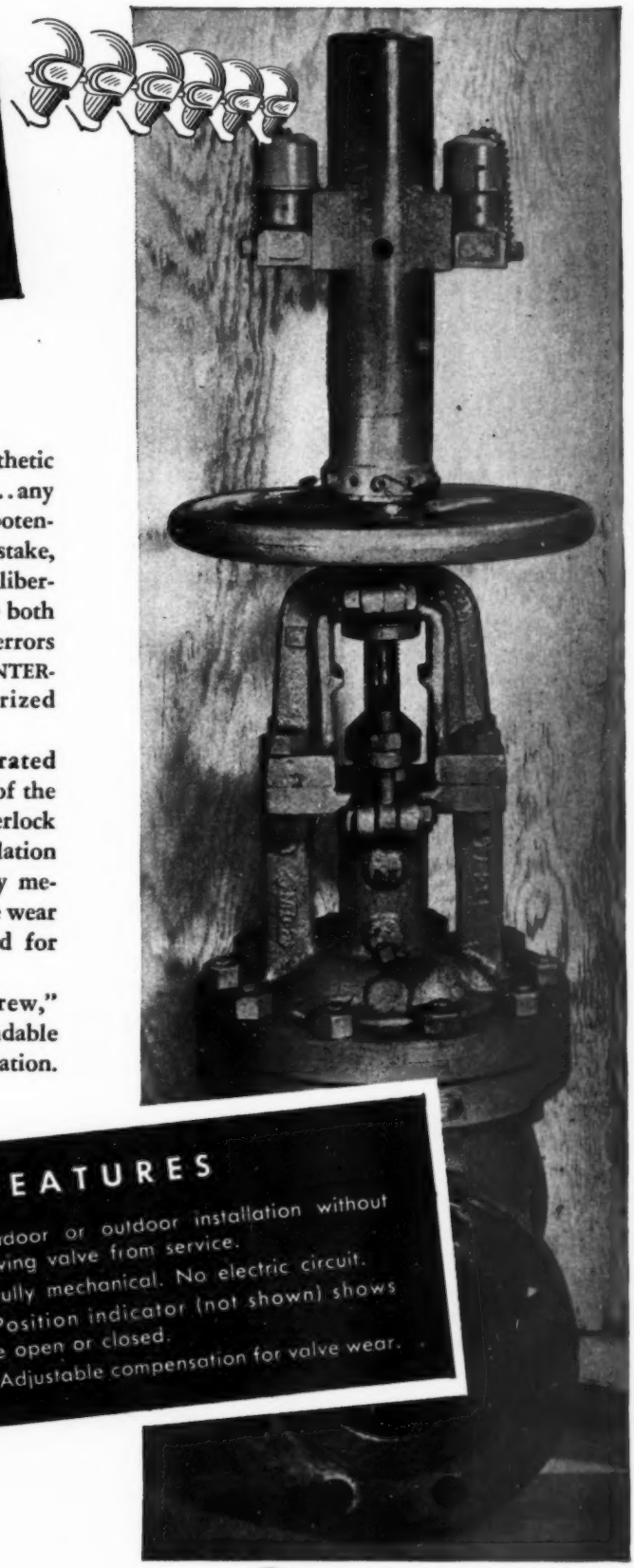
MECHANICAL GUARDIANS FOR CHEMICAL PIPE-LINES



In chemical industries, synthetic rubber plants, oil refineries... any plant, piping precious or potentially hazardous fluids... a mistake, whether unintentional or deliberate, in adjusting a chemical pipe-line valve can prove both dangerous and costly. But prevention of these human errors is easy and infallible with BENDIX-CORY* SAFETY INTERLOCKS... the locks that say "No!" to unauthorized handling of your valves.

The BENDIX-CORY SAFETY INTERLOCK illustrated gives absolute control over the opening and closing of the valve to which it is attached... and, by use of an interlock key, can also control the position of this valve in relation to any number of other valves. The unit is wholly mechanical, and fully adjustable to compensate for valve wear —one of a number of interlocks specially designed for valve protection.

As safety men of the Bendix "Invisible Crew," BENDIX-CORY SAFETY INTERLOCKS are dependable guardians for your pipe-lines. Write for full information.



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New Officials

Announcement has been made by Union Carbide and Carbon Corporation of the election of the following presidents of subsidiary companies:

J. G. DAVIDSON

Dr. Joseph G. Davidson has been elected president of Carbide and Carbon Chemicals Corporation, and Carbide and Carbon Chemicals, Ltd. He participated in the early work in synthetic organic chemistry which led to the foundation of Carbide and Carbon Chemicals Corporation, and has served in this company in technical and executive capacities since its formation.

James W. McLaughlin is the new president of the Bakelite Corporation. He has been in charge of major production operations in the industrial gases and chemicals companies of the corporation. McLaughlin will direct all plastics operations of units of the corporation, including the plastics division of Carbide and Carbon Chemicals Corporation.

Stanley B. Kirk becomes president of The Linde Air Products Company, The Prest-O-Lite Company, Inc., Dominion Oxygen Company, Ltd., and Prest-O-Lite Company of Canada, Ltd. Since 1913 he has been responsible for sales

J. W. McLAUGHLIN

S. B. KIRK

and sales management in the gas group of companies of the corporation.

Arthur V. Wilker has been elected president of National Carbon Company, Inc., and Canadian National Carbon Company, Ltd. After spending a year as head of the department of chemistry at the University of Evansville, he became associated with National Carbon Company in 1910. Since that time, with the exception of 3 years as head of the department of chemistry at Baldwin Wallace College, he has been responsible for production and important research work in the manufacture and use of carbon and graphite products.

Francis P. Gormely has been elected president of Electro Metallurgical Company, Electro Metallurgical Company of Canada, Ltd., Haynes Stellite Company, Michigan Northern Power Company, and Union Carbide Company of Canada, Ltd.

John D. Swain has been elected president of Electro Metallurgical Sales Corporation. His service with corporation units began in 1915 when he joined the Union Carbide Sales Company at Chicago.

John R. Van Fleet becomes president of United States Vanadium Corporation. Van Fleet has been identified with the natural resource supplies of the corporation for many years. He is also president of Union Mines Development Corporation.

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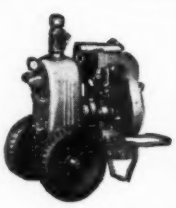

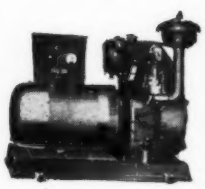

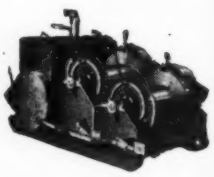

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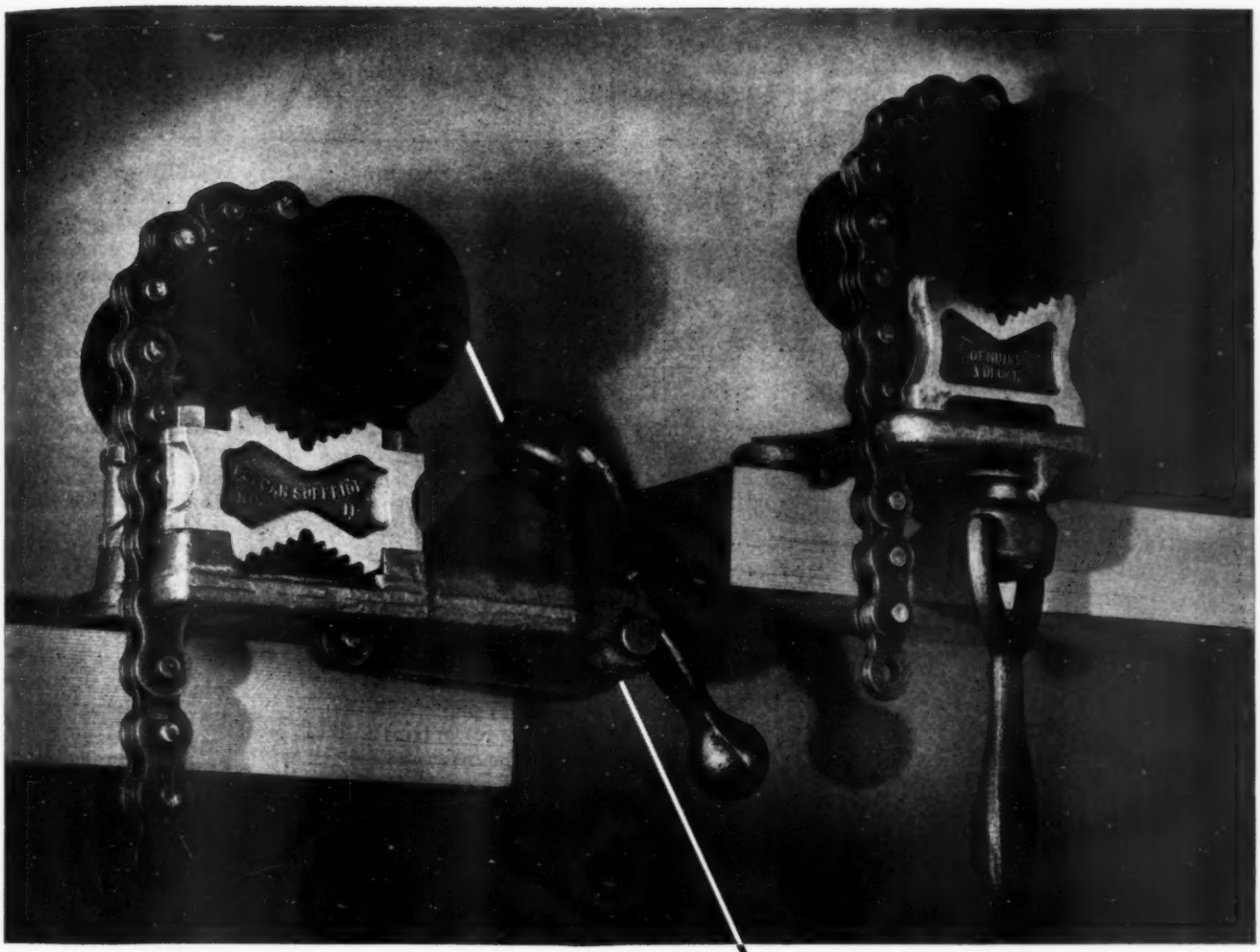

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Book Reviews

Simplified Petroleum Chemistry and Physics, *by editorial staff, Petroleum Educational Institute. Published by Petroleum Educational Institute, 704 South Spring Street, Los Angeles, California. Pages, 122. Price, $3.50, cloth bound; $3.25 plastic bound* . . . The purpose of this book is to reduce to elementary language the fundamentals of chemistry and physics for rapid assimulation by those who need this basic knowledge for their work. Salesmen, servicing men, and others will find this pictorial study simple and interesting.

Fire Pumps and Hydraulics, *by J. E. Potts and T. H. Harriss. Published by Chemical Publishing Company, 234 King Street, Brooklyn, New York. Pages, 158. Price $2.50* . . . This book describes the construction, operation, and maintenance of power-driven fire pumps, including reciprocating, rotary, and centrifugal. A clear explanation of the hydraulic principles involved is given. The volume contains valuable reference data on its subject.

The Chemical Background for Engine Research, *edited by R. E. Burk and Oliver Grummitt. Published by Interscience Publishers, Inc., 215 Fourth Avenue, New York. Pages, 297. Price, $3.50* . . . This is the second volume of Frontiers in Chemistry published under the auspices of Western Reserve University. It contains lectures given by the following distinguished scientists on the general subject of engine research: E. F. Fiock and F. D. Rossini, of the National Bureau of Standards, Washington, D. C.; F. C. Whitmore, of Pennsylvania State College; G. von Elbe, of Carnegie Institute of Technology; Bernard Lewis, Bureau of Mines, Pittsburgh, Pennsylvania, and O. Beeck, Shell Development Company, Emeryville, California.

A.S.T.M. Standards of Petroleum Products and Lubricants, *prepared by A.S.T.M. Committee D-2. Published by the American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pennsylvania. Pages, 442. Price $2.25* . . . This publication contains the 1943 Report of Committee D-2 on Petroleum Products and Lubricants, the various A.S.T.M. standard and tentative methods of tests and specifications pertaining to petroleum, and the regulations and personnel of Committee D-2 and its subcommittees and technical committees. Contents are arranged in a convenient form that expedites search for specific standards.

Industrial Plastics, *by Herbert R. Simonds. Published by Pitman Publishing Corporation, 2 West 45th Street, New York. Pages, 385. Price, $4.50* . . . The second edition of this volume has been revised to include plastics in wartime. There is a comprehensive but concise presentation of plastics from the standpoints of engineering, historical and economic background, and its role in the present war.

Houston a District Office

Conversion of the Houston, Texas, sales office of the National Tube Company into an independent district office has been announced in Pittsburgh by National Tube Company, a subsidiary of United States Steel Corporation. Forrest A. Marsh of Houston has been appointed district sales manager.

Prior to the conversion, the Houston sales office operated under the Dallas, Texas, district.

Marsh has been a resident of Houston since 1933. Since 1936 he has been division sales manager in that city.

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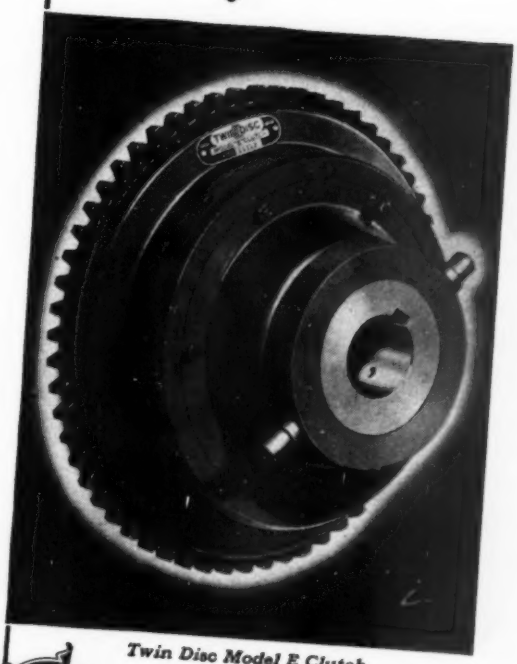

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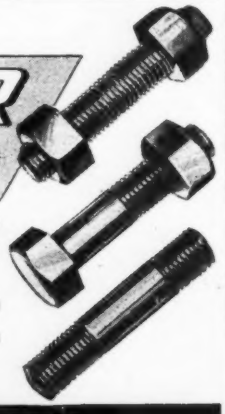

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INFORMATION ON ALL TOOLS made by Grant Oil Tool Company may be obtained by writing to the company at 2042 East Vernon Avenue, Los Angeles 11, California. Specifications and functions are presented clearly and briefly for each Grant tool.

"RADIOACTIVITY WELL LOGGING" is a complete story on the subject published by Lane-Wells Company, 5610 South Soto Street, Los Angeles 11, California. Copies are available on request. Details of the service, equipment, and applications, with typical and sample logs from various fields are contained in the 52 pages.

REPRINTS OF "Maximum Service From Well Surveying Equipment" can be obtained from Sperry-Sun Well Surveying Company, 1608 Walnut Street, Philadelphia, Pennsylvania. The article points out methods of getting the best service out of well surveying equipment.

"PUMPS, HYDRAULICS, AIR COMPRESSORS" is a comprehensive guide for engineers, pump operators, and mechanics. It contains 1650 pages and 1654 illustrations. It is available at $4 from the publishers, Audel, Publishers, 49 West 23rd Street, New York 10, New York.

THE MARLEY COMPANY, INC., 3001 Fairfax Road, Kansas City, Kansas, has just released a book for industrial users of water for cooling purposes. It presents the engineering principles involved and discusses best modern practice in the selection, application, operation, and maintenance of each type of water cooling equipment. "Fundamentals of Water Cooling" will be sent on request.

PRECISION PRODUCTION TOOLS are illustrated and described in catalog No. 44, recently issued by Acme Tool Company, 200 Church Street, New York 13, New York. The catalog features unusual production tools that have contributed to increased production.

ELASTIC STOP NUT CORPORATION OF AMERICA, Union, New Jersey, has published a catalog showing complete specifications, sizes available, and detailed tests of the latest ESNA spring lock fastener. The fastener is composed of two parts, both of them installed permanently on the fixed part as well as the removable part of the cowling or other assembly.

A NEW CALCULATOR has been produced by The Lincoln Electric Company, Cleveland, Ohio, and is available at 25 cents, postpaid, in the United States, 50 cents elsewhere. It is designed for readily determining the welding preheating and interpass temperatures of steels in cases where experience indicates the need for preheating to obtain best results.

Returns to West

Henry W. Pullman, export service manager, Baker Oil Tools, Inc., will return to Los Angeles about the middle of June from New York and other eastern points.

R. C. Baker, Jr., secretary-treasurer, has returned from an extensive trip throughout the East, where he accompanied Pullman. During his return trip he visited field operations in Illinois and in the Houston area. He also took time off to visit the company's former airplane pilot, Ted R. Hurlburt, test pilot for the Ford Motor Company at Willow Run.

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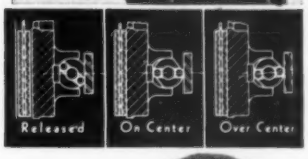

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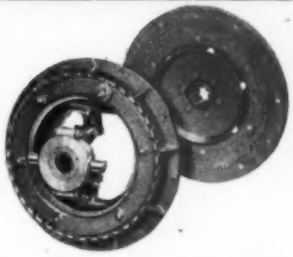

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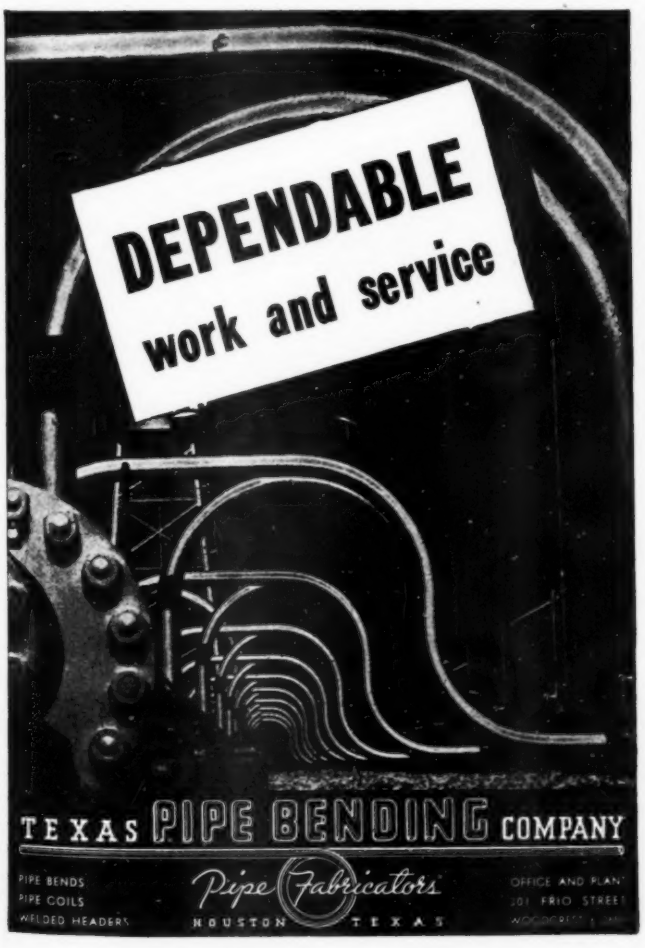

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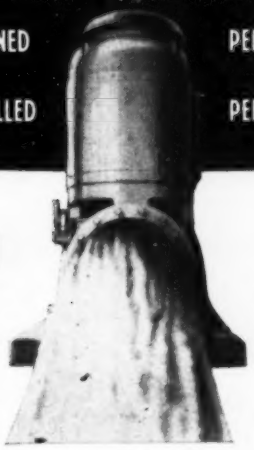

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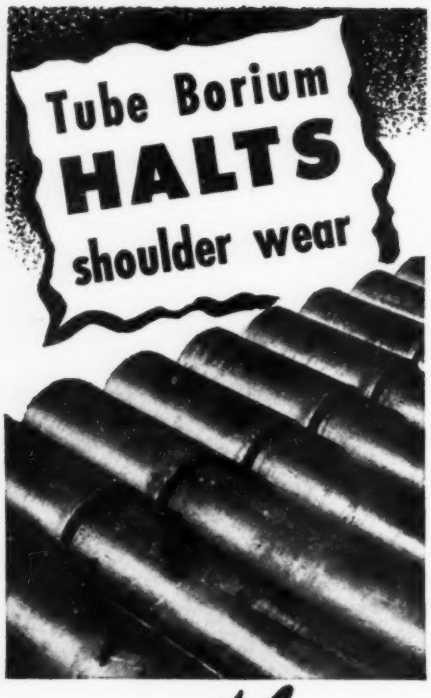

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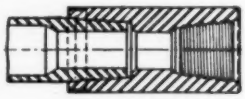

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